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Development and Evaluation of Methods for Surveying Fish Populations in Nearshore Waters

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Scottish Industry Science Partnership Report

Report no. 04/10

SISP project 005/09

Development and evaluation of methods for surveying fish populations in nearshore waters

Final Report

November 2010

marine scotland science

Scottish Industry Science Partnership Project

Development of methods for surveying nearshore fish populations, Ref. MS/0114

Final Report, November 2010

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Executive Summary

1. Nearshore areas provide critical habitat for a range of fish species targeted by commercial and recreational fisheries, both of which make an important contribution to local economies in rural areas. However, established trawl survey methods are not suited to many nearshore areas, owing to shallow depths, obstructions on the sea bed or vulnerable habitats, so there is a lack of information on fish abundance in these areas.

2. The aim of the present project was to develop and test survey methods applicable to Scottish inshore waters, focussing on baited underwater cameras, fish traps, systematic rod-and-line surveys and observations of fish bycatch in crustacean trap fisheries, and to carry out associated studies of fish movements.

3. A lightweight baited underwater camera system was developed that could be deployed by two persons from inshore fishing vessels and small boats. The system consisted of a digital camera and strobes in underwater housings, mounted on a frame of aluminium alloy tubing, suspended above the seabed by sub-surface floats on one leg of a J-shaped mooring. The camera was baited with oily fish and a standardized 1 hour deployment period was used, to minimize variability in results due to changing tidal currents and bait degradation. Photographs were taken at 30 second intervals throughout the deployment period. On retrieval, the photographs were examined to derive indices of fish abundance, such as the time to first arrival of particular species (TFA) and the maximum number of individuals seen in the field of view at any time during the deployment (MaxN).

4. The BUC system was developed and tested in the Firth of Clyde and then deployed at a range of other locations in Lamlash Bay, Arran, the Firth of Lorn, the Sound of Mull, Loch Sunart, Loch Etive, around Skye, Galloway and in Orkney.

5. The BUC system was successfully deployed from a range of types of vessel in depths down to 40 m. Over thirty species of fish were recorded in total, including species of commercial interest, with lesser spotted dogfish, *Scyliorhinus canicula*, being the most commonly recorded. The number of species and indices of abundance were highest at sites on the Galloway peninsula.

6. When compared within a single area, BUC detected more species than angling or fish traps, but less than in visual transects by SCUBA divers. BUC shows great potential as a cost-effective survey method, able to show relative differences in abundance between areas. It is likely that it would also be effective in detecting temporal trends, though this was outside the scope of the present project.

7. A Norwegian design of collapsible cod trap, Roscoff traps designed for common prawns and Norway lobster creels were investigated as fish traps. There were differences in catch rates and species composition related to the trap design. Roscoff traps appeared to be suitable for sampling juvenile cod (*Gadus morhua*) in complex habitat in shallow water, whereas collapsible cod traps are suitable for larger fish, but need to be fished in greater numbers to obtain sufficient data.

8. Creel fisheries were surveyed by questionnaire and by on-board catch sampling. A range of fish species is taken as bycatch in creels, with some obvious differences in species composition between crab fishing and Norway lobster fishing in relation to the depths and ground types fished. The present results suggest that the catch rates of commercial

fish species may be too low for creeling to be a useful way of monitoring fish stocks, but sampling throughout the year in different areas would be desirable to assess this more fully.

9. A small-scale pilot study in Galloway indicated some potential for rod-and-line surveys to generate useful information on the abundance of certain fishes. The Scottish Sea Angling Conservation Network and the Scottish Shark Tagging Project already collect information on catches of angling target species and on tagging and recaptures of tagged fish. This would be augmented by encouraging anglers to submit returns with an indication of fishing duration even when they have not caught anything. However, we were unsuccessful in recruiting volunteers to participate in a randomized angling survey. Further work is required to develop statistically robust angling surveys in which volunteer anglers would be willing to participate. Experience indicates that payment of expenses would be required for volunteers to agree to fish according to a survey protocol.

10. To study movements of a species of interest to recreational sea anglers, spurdog (*Squalus acanthias*), ten specimens in Loch Etive were tagged with data storage tags designed to record water temperature and depth. To date, one tag has been recovered and the downloaded data shows an interesting pattern of nocturnal movements into shallow water. More information should become available when more of the tagged spurdog are recaptured.

11. The following recommendations arise from the present study:

    a. To improve our understanding of baited methods of surveying fish and to develop improved estimates of abundance, modelling studies of bait odour dispersal and fish responses are required, building on previous work in this area.

    b. Further trials of baited underwater cameras at different sites and under different conditions are required to assess the degree of variability in the different types of abundance index that can be derived.

    c. Further work to compare different survey methods is required at sites with greater fish abundance, e.g. at sites around the Galloway peninsula.

    d. A BUC system with greater depth limit (e.g. 200 m) should be developed to extend the range of habitats in which it can be used to include other species of interest.

    e. Further work is required to assess the size and species selectivity of different designs of fish trap.

    f. An intensive pilot survey of an area of interest, such as an actual or proposed marine protected area, by BUC and fish traps would provide a good test of the ability of these methods to generate data of use to inshore fishery managers and conservation interests.

    g. Seasonal sampling of fish bycatch in Norway lobster and crab creel fisheries is desirable to further assess the potential for creel fisheries to be used to monitor fish populations.

    h. Ongoing analysis of recreational sea-angling catch and tagging records should be encouraged and supported by Marine Scotland.

    i. There should be continued engagement between recreational sea-anglers and fishery scientists in Marine Scotland and universities.

Development of methods for surveying nearshore fish populations

Scottish Industry Science Partnership Project Report, Ref. MS/0114

P. Smith, I. Burrett, D. Bailey, F. Neat, D. Donnan, K. Dunlop, J. Thorburn, R. Milligan, S. Bastiman, J. Dodd

1 Introduction

Nearshore areas provide critical habitat for a range of fish species targeted by commercial and recreational fisheries, both of which make an important contribution to local economies in rural areas. The economic value of recreational sea-angling in Scotland, for example, is estimated to be in the region of £150M to £200M *per annum*. Understanding the sustainability of fisheries exploiting these species requires information on their distribution, abundance and patterns of movement. This type of information is particularly crucial in relation to the appropriate design of networks of marine protected areas, as envisaged in the Marine (Scotland) Act 2010 and in international obligations under the OSPAR convention and the European Marine Strategy Framework Directive.

However, established trawl survey methods are not suited to many nearshore areas, owing to shallow depths, obstructions on the sea bed or vulnerable habitats, so there is a lack of information on fish abundance in these areas. New sampling methods are therefore needed that are practicable, effective and efficient. The aim of the present project was to develop and test survey methods applicable to Scottish inshore waters, focussing on baited underwater cameras, fish traps, systematic rod-and-line surveys and observations of fish bycatch in crustacean trap fisheries, and to carry out concomitant studies of fish movements.

1.1 Baited underwater cameras

Baited underwater camera (BUC) systems have been used for about 40 years for studying scavenging fish in the deep ocean, but have received increasing interest recently for surveying fish abundance in shallower waters, for example, in Alaska, New Zealand and Australia. In 2006, Fisheries Research Services (now Marine Scotland-Science) scientists experimented with a BUC system for assessing fish abundance at the Buzzard platform site in the North Sea from FRV *Scotia* and in April 2009 further trials were undertaken around the mouth of Loch Ewe by two of the present project team (Neat and Bailey) from FRV *Alba na Mara*. Further development work of a lightweight system was undertaken at Millport in June to August 2009 in an M.Sc. project supervised by Bailey and Smith. With these systems, a camera records fish attracted to bait. Data on the arrival times of fish can be used to estimate the population density. There are various designs of BUC system, relating to features such as type of camera, illumination, viewing angle and attractant. Developments in camera technology now allow compact, lightweight systems that can be deployed from small vessels, such as inshore fishing vessels.

1.2 Portable fish traps

Various designs of portable trap have been used in commercial and artisanal fisheries in other parts of the world, as well as for research. Marine Scotland scientists have trialled the use of fish traps in a variety of locations over the last few years, and they were deployed in conjunction with the BUC system tested on the FRV *Alba na Mara* cruise in April 2009. The

University of Newcastle recently compared collapsible Norwegian cod traps with a range of other sampling methods in Yorkshire (B. Wigham, pers. comm.). Compared with BUC systems, traps have the advantage of allowing live fish to be sampled, but the time sequence of arrivals at the gear is not known. Interpretation of trap data needs to take account of complications arising from variable attraction of fish to the bait and differing probabilities of entry to and retention within the trap, leading to issues of selectivity and trap ‘saturation’. Fishing experiments with different soak times can be used to estimate changing rates of ingress and escapement, which in turn can be used in calculating standardized indices of population density.

Survey of fin-fish bycatch associated with commercial shellfish creel operations
Baited traps (i.e. ‘pots’ and ‘creels’) are widely used in Scottish inshore waters to catch crustaceans, but in certain places and times, they are known to take a bycatch of fish, including fish of commercial significance, such as juvenile cod. The amount and geographical extent of trap fishing for crustaceans may provide a valuable way of monitoring changes in the abundance of certain fish species over large areas, either from catch sampling by fisheries scientists, or from selected fishers’ in different areas reporting fish bycatch (so-called ‘fisher self-sampling’ schemes are being developed in various areas, often in support of environmental accreditation of the fishery).

1.3 Rod-and-line surveys

Rod-and-line fishing is another potential low-impact survey method for selected species in nearshore areas. Measures of catch per unit effort (CPUE) have been used as indices of abundance in certain commercial and recreational rod-and-line fisheries, more commonly in fresh water, but also in the sea (Haggarty & King, 2006). However, catch statistics often lack data on factors that can influence the reliability of such indices, such as fishing effort, details of fishing gear and bait or lures, level of fishers’ skill and exact fishing locations and conditions. Variation in these confounding factors could be minimised with a group of motivated and experienced volunteer anglers following a standardised survey protocol to generate more reliable indices of population density. Sampling by rod and line can also provide fish for tagging in studies of fish movements or for mark-recapture estimates of population density.

1.4 Fish tagging

Each of the survey methods above is potentially influenced by patterns of fish movement. It is therefore desirable to obtain information about the mobility of target species and the extent to which they undertake directed movements. Furthermore, while surveys of population density can provide snapshots of geographical distribution, knowledge of movement patterns is required to understand the spatial structuring of fish populations. Conventional mark-recapture methods (tagging and releasing fish with inert numbered tags and recording the time and place of their recapture) can provide useful information on movements, providing it is possible to tag many individuals and recapture a sufficient proportion of them over a range of time intervals. Continuing developments in electronic tags provide more sophisticated means of monitoring fish movements near-continuously. Data storage tags are encapsulated electronic devices with sensors for recording variables such as water temperature and depth. If the fish is recaptured, the data can be downloaded from the tag to ascertain the conditions experienced by the fish and infer its location during the recording period. However, data storage tags are expensive, so only a limited number can be deployed compared with conventional tags. A combination of conventional and electronic tagging can provide information that could not be obtained by either method alone.

1.5 Objectives

The present project aimed to develop and evaluate four methods of surveying fish in inshore waters and to obtain data on fish movement patterns. Specifically, the objectives were:

1. to develop a baited underwater camera system to be deployed by a vessel in inshore areas
2. to develop baited fish traps to be deployed by a vessel in inshore areas
3. to administer an observer programme that will assess the by-catch of fish in baited traps set for crustaceans
4. to design and coordinate a method of systematic rod-and-line sampling for selected species
5. to develop a research programme aimed at obtaining information about movement patterns of selected inshore fish species in the survey areas using conventional fish tags and electronic data storage tags
6. to conduct trials of these methods in: (a) a well-studied area where the habitat is well known and the fish fauna may be characterized by trawling; and (b) several different nearshore sites with varying expected abundance and species composition of fish
7. to assess the effectiveness, efficiency and selectivity of the different methods and evaluate their utility.

2 Development of a baited underwater camera system

The use of baited underwater cameras (BUC) to gather information and monitor fish populations was originally developed for use in the deep sea environment to study fish populations at depths inaccessible to scuba divers (Bailey *et al*. 2007). The deployment of BUCs has many potential advantages as a survey methodology. Their use causes little damage to seabed communities, multiple camera systems can be in use simultaneously, making very efficient use of vessel time. BUCs can be deployed from small vessels without specialist winches or other deck gear, and by non-expert personnel. Once the underwater images have been downloaded, they form a permanent record of the sampling site, which can be analysed by more expert personnel, or used to train new surveyors.

The above attributes should make BUCs a suitable method for surveying areas where trawling is impossible or inappropriate (e.g. marine protected areas, offshore energy installations with subsea equipment and cables). They can also be deployed where diving is not possible due to the depth, conditions, or lack of suitably qualified team. These benefits will only be obtained if BUCs are shown to work as effectively in UK waters as they do in the other countries.

2.1.1 Camera system

A baited underwater camera system was developed to survey fish populations on the West Coast of Scotland. The design consists of a digital stills camera (SeaLife DC800 or DC1000) enclosed in a SeaLife underwater housing and two variable-power digital slave strobe light unit (SeaLife Digital Pro Flash model SL961 or Epoque ES-23DS) supported on an L-shaped frame. In early prototypes, the frame was of glass reinforced plastic (GRP) angle, but later this was replaced with aluminium tube of 26 mm outer diameter jointed with tube clamps, for greater robustness (Fig. 2.1). The strobe light units were attached to the camera by optical cables, which synchronized the flash with image capture. The camera was set to automatic exposure and a time lapse mode in which a single image was captured every 30 seconds.

The camera system was secured into a protective ABS box by its tripod mounting. The box was mounted on a U-bracket with pivots that allowed the vertical angle of view to be adjusted. The camera bracket was bolted to the vertical element of the frame and the camera box was angled downwards to view the bait container (a small mesh bag containing herring, *Clupea harengus*, or mackerel, *Scomber scombrus*) attached to the far end of a horizontal pole. The frame was designed to provide adequate support and protection for the camera system, while minimising weight and the three-dimensional structure, which might affect fish behaviour.

Figure 2.1 Photograph of the baited underwater camera system suspended in air.

2.1.2 Camera testing

An early version of the camera system was deployed in the Northern Red Sea. This camera and the fieldwork costs were paid for by other sources, including an EU funded project. This work established the deployment methods and some of the camera settings required for baited camera work. Due to the light levels and water clarity, the strobes were not necessary.

On deploying the system, and the copies of it purchased under the SISP project, in more turbid Scottish conditions it became necessary to make modifications to the camera system. In particular it was important to deal with the problem of “backscatter” from suspended particles between the camera and bait. Repeated deployments were made from the Keppel Pier (UMBSM), adjusting camera and lighting settings and comparing the resulting images. The settings listed in Table 2.1 are those that were found to produce the optimal images.

2.1.3 Deployment methods

When deployed from a boat, the camera frame was lowered on a J-shaped mooring and supported upright in the water column by two mid-water buoys and weighted by a 10 kg concrete block (Fig. 2.2). This weight was also attached to a 15 kg block by a 4 m length of rope, or later 2 m of chain, which was in turn attached to a surface buoy. This mooring was designed to avoid movement of the camera frame caused by motion of the marker buoy and buoy line. On some deployments, a Valeport BFM105 current meter was suspended horizontally between the mid-water buoys and the camera frame to record current speed and direction. In other deployments, a Nortek Aquadopp acoustic doppler current meter was attached to the vertical element of the camera frame.

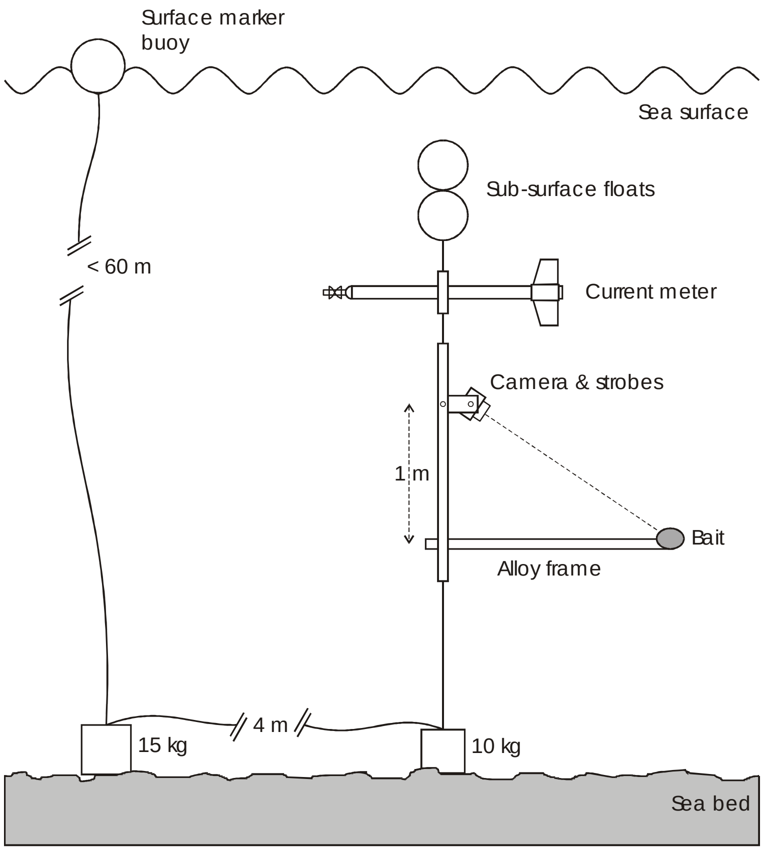

Figure 2.2 Schematic diagram of baited underwater camera frame and J-shaped mooring.

Table 2.2 gives an overview of the general procedures followed to deploy the baited underwater camera system from a vessel. The exact procedure for lowering the camera system into the water, and recovering it after deployment depended on the specific design of the vessel. The use of a winch, power block or pot hauler is useful but not essential and the camera system can be hauled by hand if necessary.

In low current conditions (i.e. only a small ballast block required) and where the seabed is particularly fragile, the camera system can be hand-deployed by divers. In the case of diver deployment, the weight of the camera is supported by a lift-bag during descent. The camera system can then be hauled to the surface at the end of the deployment, or sent up by a diver by inflating the lift bag and releasing the system. These methods were used extensively during the Red Sea work and were described in the interim report.

Table 2.1 SeaLife DC 800/1000 digital cameras settings used throughout baited underwater camera deployments made around Scotland.

Mode	Setting
Scene mode	Extflash Mode
Size	3264 × 2448
Quality	Superfine
Sharpness	Hard
White Balance	Extflash Auto
ISO	Auto
Metering	Centre
Focus	Infinity
Flash	Infinity

Table 2.2 General procedure followed to deploy the baited underwater camera from a vessel.

<table>
<tr><th>Preparation</th><th>Immediately prior to deployment</th><th rowspan="8">60 minute deployment</th><th>Post deployment</th></tr>
<tr><td>Camera and strobe batteries charged</td><td>Full/fresh bait bag attached</td><td>Camera and strobe housings rinsed (if final deployment)</td></tr>
<tr><td>Camera and strobe O-rings checked for damage. Strobe O-rings greased with silicon grease.</td><td>Check that camera and strobes firing simultaneously</td><td>Camera removed and images downloaded and backed up</td></tr>
<tr><td>Rigging and buoyage attached</td><td>Mooring deployed, camera frame block first</td><td>Bait replaced</td></tr>
<tr><td>Check that camera and strobes operating correctly and firing simultaneously</td><td>On blocks reaching bottom, buoy line tensioned to separate mooring blocks</td><td>Batteries for strobes and camera changed if necessary</td></tr>
<tr><td>Bait prepared</td><td>Buoy line released</td><td></td></tr>
<tr><td>Empty memory card inserted</td><td></td><td></td></tr>
<tr><td>Check that all joints tightly fixed</td><td></td><td></td></tr>
</table>

2.1.4 Data Analysis

Stills photographs were processed in Picassa (Google Inc.) to increase their image brightness and contrast, and then viewed individually. The species and number of individual fish were recorded for each image. The maximum number of each species seen throughout the whole deployment (MaxN) and the time from the camera deployment to the first arrival of each species were recorded. Time to first arrival was used to estimate abundance, based on the principle that if fish population density is high, a randomly dropped camera is likely to land close to a fish, and therefore it will quickly arrive in the field of view. Where fish are more sparsely distributed it should, on average, take longer for the first fish to arrive. This is the simplest and least sophisticated estimate of abundance, and presented here only as an example of the type of ongoing work that the SISP data will support.

2.1.5 Baited underwater camera deployments

Camera deployments were made at four sites around the Isles of Cumbrae: Clashfarland Point (55° 45.58′ N, 4° 53.36′ W), Skate Point (55° 47.06′ N, 4° 55.50′ W), Trail Island (55° 43.12′ N, 4° 56.24′ W) and Fairlie Patch (55° 45.59′ N, 4° 53.34′ W) between 28 May and 4 June 2010. At each site, deployments were made at each of four depths (5, 10, 15 and 20 m).

Camera deployments were made at a variety of locations inside and outside the no take zone in Lamlash Bay at a depth of 15 m.

From 1–7 June 2010, a baited underwater camera survey was conducted at four sites around the Island of Kerrera, Firth of Lorn: Loch Feochan (56° 21.04′ N, 5° 31.78′ W), off Kerrera Castle (56° 22.61′ N, 5°31.86′ W), Heather Island (56° 24.25′ N, 5° 30.24′ W) and at the North Spit of the Island (56° 25.56′ N, 5° 30.34′ W), to investigate the fish species and abundance in the area and at a range of depths (15, 20, 25 and 30 m).

The effect that habitat type has on the fish species and numbers observed with the camera system was tested in Loch Sunart. Deployments were made in rocky and muddy habitats, which were selected with reference to the SNH Commissioned report ‘Broad scale mapping of sublittoral habitats in Loch Sunart, Scotland’ (Bates *et al*., 2003). In the Sound of Mull, a similar exercise was conducted, though here the camera stations were selected on the basis of predictions of seabed type from sidescan sonar.

2.1.6 Fish traps

At many of the BUC deployment sites in Lamlash Bay, the Firth of Lorn, Loch Sunart and Sound of Mull, fish traps were also deployed after the camera deployments (Table 2.3). A Norwegian design of collapsible cod trap (Medley Pots, http://www.medleypots.co.uk/index.php?h=3&p=8) was deployed on individual moorings in the late afternoon and hauled the following morning. Traps were baited with the same bait as the BUC (herring or mackerel) in a bait sock suspended in the middle of the trap. In the commercial trap fishery for cod in Northern Norway, this type of trap is usually fished in depths greater than 70 m (Furevik & Løkkeborg, 1994), where entrapment of seals and otters is unlikely. However, in shallower water within the depth limit of the BUC system, the potential for trapping and drowning otters and young seals was a concern. Otters are one of the features for which the Loch Sunart Special Area of Conservation has been designated, and so the entrances to the traps were modified with twine to reduce the apertures (Fig. 2.3).

Table 2.3 Locations of fish trap deployments.

Deploy-ment	Date hauled	Area	Site	Latitude (North)	Longitude (West)	Depth (m)
1	29/06/2010	Lamlash Bay	Holy Is E	55º 32.011′	5º 4.226′	16
2	29/06/2010	Lamlash Bay	Lamlash Harbour	55º 31.793′	5º 7.429′	15
3	30/06/2010	Lamlash Bay	Holy Is E	55º 31.477′	5º 3.761′	16
4	30/06/2010	Lamlash Bay	Lamlash Bay N	55º 32.283′	5º 6.389′	16
5	30/06/2010	Lamlash Bay	Holy Is SW	55º 31.361′	5º 5.009′	15
6	02/07/2010	Kerrera	Heather Island	56º 24.323′	5º 30.069′	17
7	02/07/2010	Kerrera	Sgeiran Dubha	56º 22.583′	5º 31.784′	18
8	02/07/2010	Kerrera	Kerrera N	56º 25.628′	5º 30.266′	17
9	03/07/2010	L. Sunart	Oronsay NE	56º 39.856′	5º 55.187′	18
10	03/07/2010	L. Sunart	Oronsay SE	56º 39.599′	5º 54.068′	17
11	03/07/2010	L. Sunart	Oronsay W	56º 39.205′	5º 57.379′	17
12	04/07/2010	L. Sunart	Auliston Point	56º 39.059′	5º 59.978′	16
13	04/07/2010	L. Sunart	W of Camus nan Liath	56º 39.078′	5º 58.147′	19
14	04/07/2010	L. Sunart	Oronsay N	56º 40.177′	5º 55.921′	16
15	05/07/2010	S of Mull	Rubh'a Ghlaisich	56º 34.302′	5º 58.933′	15
16	05/07/2010	S of Mull	Ardnacross burn	56º 34.113′	5º 58.938′	16
17	05/07/2010	S of Mull	Arla Rock	56º 33.897′	5º 58.795′	13
18	06/07/2010	S of Mull	Kintallen	56º 33.178′	5º 58.156′	17
19	06/07/2010	S of Mull	Aros Castle	56º 32.015′	5º 57.446′	13
20	06/07/2010	S of Mull	Outer Salen Bay	56º 31.913′	5º 56.199′	17
21	07/07/2010	S of Mull	Duart Bay	56º 27.298′	5º 40.148′	14
22	07/07/2010	S of Mull	Rubh'a' Ghuirmein	56º 27.575′	5º 40.508′	13
23	07/07/2010	S of Mull	E of Craignure	56º 27.908′	5º 41.122′	13

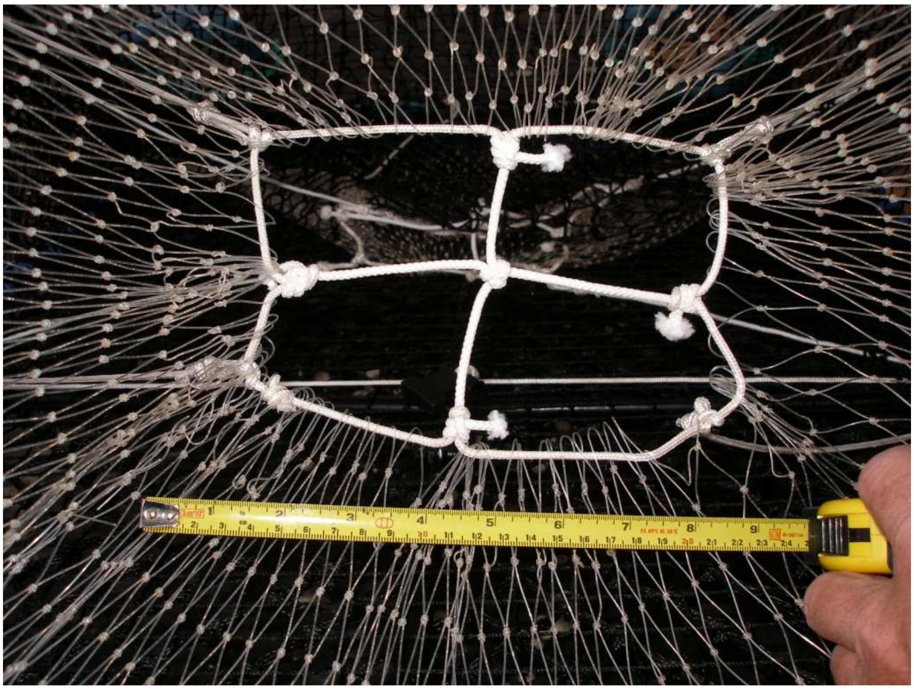

Figure 2.3 Photograph showing the monofilament funnel entrance to the collapsible cod trap, modified with additional twine to reduce the size of the aperture to act as an otter guard.

2.2 Results

2.2.1 BUC observations

The species observed across all camera deployments and the number of deployments in which they were seen are given in Table 2.4. The most commonly observed species by some margin was the lesser spotted dogfish, *Scyliorhinus canicula* (Fig. 2.4). The mean number of species observed varied among study areas and was highest in Galloway (Fig. 2.5). Abundances at Galloway are significantly higher than those found in other areas. The deployments in Galloway were made in an area of known high fish abundance (Fig. 2.6), so are not necessarily representative of the area, but they do demonstrate how variations in fish communities can be detected by the BUC method. The Clyde deployments detected the lowest number of species, significantly lower than Galloway, Loch Etive or Skye.

A plot of the number of species recorded against the number of camera deployments shows that as more deployments are made, additional species are observed (Fig. 2.7). It does not appear that an asymptote has been reached, so that additional deployments may add to the number of species observed.

Up to nine species were recorded in individual deployments. The number of species recorded did not vary in any obvious pattern with depth (Fig. 2.8).

The mean time to first arrival at the camera varied among study areas. Galloway has the lowest first arrival time, and therefore probably had the highest fish abundances. The first arrival times were highly variable, especially where only a few deployments were carried out, and probably reflect patchy distribution of fish (Fig. 2.9).

There was an apparent trend towards longer first arrival times with increasing depth (Fig. 2.10), but this was entirely driven by the relationship for *Scyliorhinus canicula* in the Firth of Lorn (Fig. 2.11). By taking account of current speeds during the deployment and estimated swimming speed of dogfish, it is possible to convert time to first arrival to estimates of population density (Fig. 2.12). These estimates suggest that this species becomes less abundant with increasing depth, although the trend is largely driven by very low abundances in the Firth of Lorn.

Another species commonly recorded by the BUC system was the goldsinny wrasse, *Ctenolabrus rupestris*. There was little apparent relationship between the abundance of this species and depth, at least over the limited depth range examined here (Fig. 2.13).

2.2.2 Fish trap catches

Five species of fish were recorded in the collapsible fish traps, of which dogfish was the most common (Table 2.5). The traps also caught a range of scavenging invertebrates, particularly portunid crabs, indicating the traps sat on the bottom. It would be possible to increase the flotation of the traps to hold them off the bottom and reduce the crustacean catch, which may have deterred fish entry (Furevik *et al*., 2008).

Table 2.4 List of species recorded by baited underwater camera, in ranked order of the number of camera drops in which the species was observed.

Species	Rank	Number of drops species observed
Scyliorhinus canicula	1	23
Ctenolabrus rupestris	2	14
Trisopterus minutus	3	9
Pollachius pollachius	4	6
Pollachius virens	5	6
Pomatoschistus microps	6	6
Thorogobius ephippiatus	7	6
Eutrigla gurnardus	8	5
Gobiusculus flavescens	9	5
Merlangius merlangus	10	5
Pomatoschistus minutus	11	5
Crenilabrus melops	12	3
Gadus morhua	13	3
Labrus bergylta	14	3
Labrus mixtus	15	3
Raja clavata	16	3
Scyliorhinus stellaris	17	3
Centrolabrus exoletus	18	2
Gobius niger	19	2
Lesueurigobius friesii	20	2
Limanda limanda	21	2
Melanogrammus aeglefinus	22	2
Pleuronectes platessa	23	2
Squalus acanthias	24	2
Trisopterus sp.	25	2
Unknown small grey fish	26	2
Anguilla anguilla	27	1
Atherina presbyter	28	1
Unknown blenny	29	1
Unidentified gurnard	30	1
Molva molva	31	1
Pomatochistus pictus	32	1
Raja montagui	33	1
Scomber scombrus	34	1
Unknown goby	35	1

Table 2.5 Species abundances recorded in collapsible fish traps, June to July 2010. See Table 2.3 for details of locations.

Deployment number	Species																		
	Scyliorhinus canicula	*Limanda limanda*	*Gadus morhua*	*Gaidropsarus vulgaris*	*Labrus mixtus*	*Cancer pagurus*	*Necora puber*	*Liocarcinus depurator*	*Liocarcinus corrugatus*	*Carcinus maenas*	*Hyas areneus*	*Macropodia rostrata*	*Munida rugosa*	*Pagurus bernhardus*	*Homarus gammarus*	*Nephrops norvegicus*	*Natatolana borealis*	*Ophicomina nigra*	*Asterias rubens*
1	2						1	4		42						1			
2	3					5	3												
3						17	15	14											
4							2	7		1					2				
5	2																1	16	
6	3	2				1		18		1			1						
7	4					3							2						
8	3							10											
9								6		4			1						
10							2						1						
11		1					2	13					1						
12					1	2	7								1				
13						2		5					10						
14			1			1	4						2						
15	7						4	1		7	1								
16							1			2		1	1						
17	1			1			4		1										
18	3						1	1		11									
19	11						1	15		24				14		1			
20	4						1	2		1			6						
21	4						16	1		19									
22	3					2	2	7		51				1					4
23	7									49									

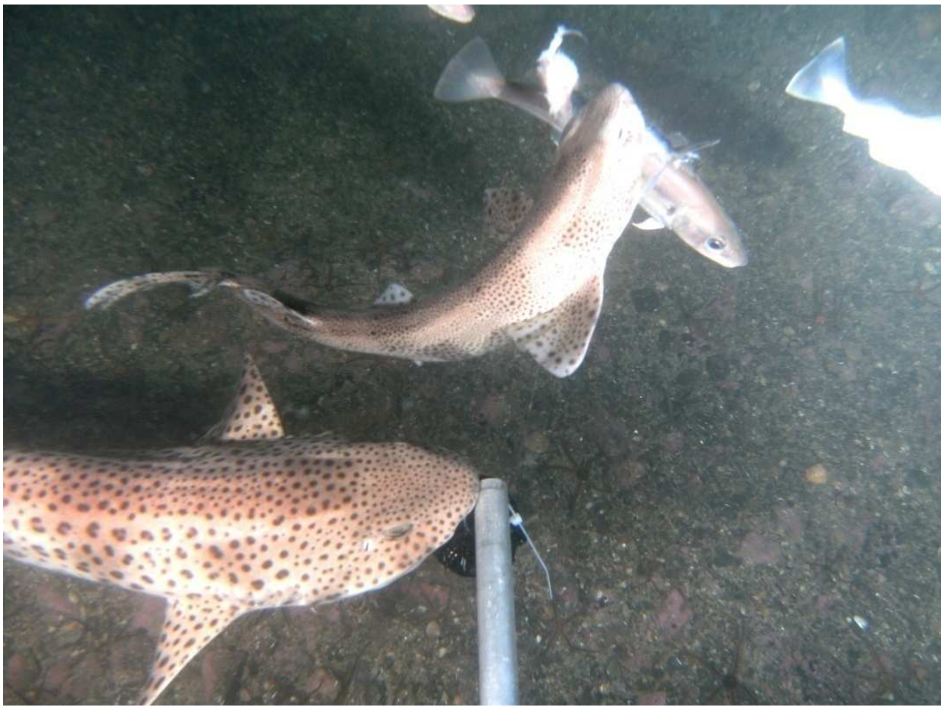

Figure 2.4 The lesser-spotted dogfish *Scyliorhinus canicula* was the most commonly observed species at the BUCs.

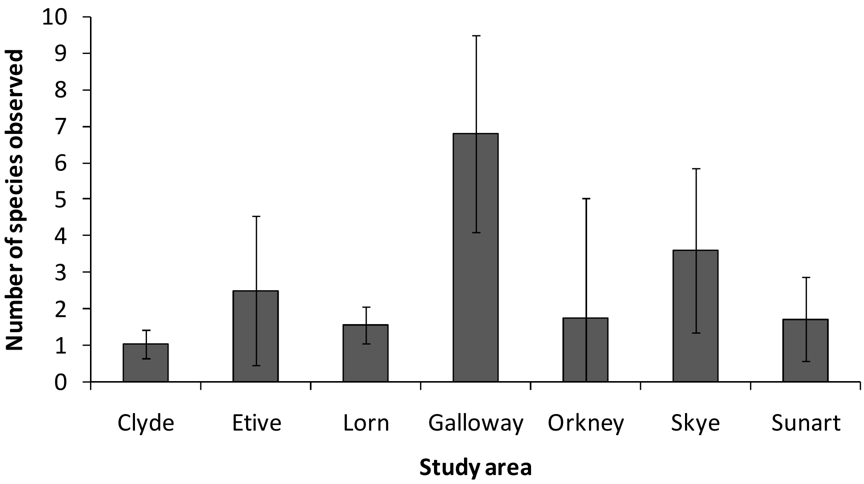

Figure 2.5 Mean number of species (±95% confidence limits) observed at camera deployments in each of these study areas.

Figure 2.6 High local abundances of fish as seen by the BUC at sites in Galloway.

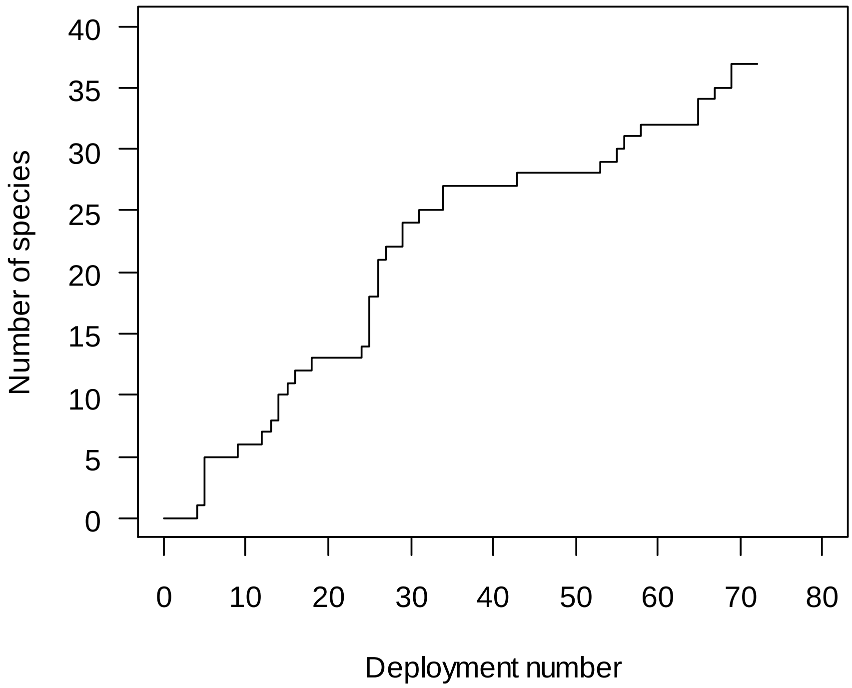

Figure 2.7 Species accumulation with increasing numbers of camera deployments.

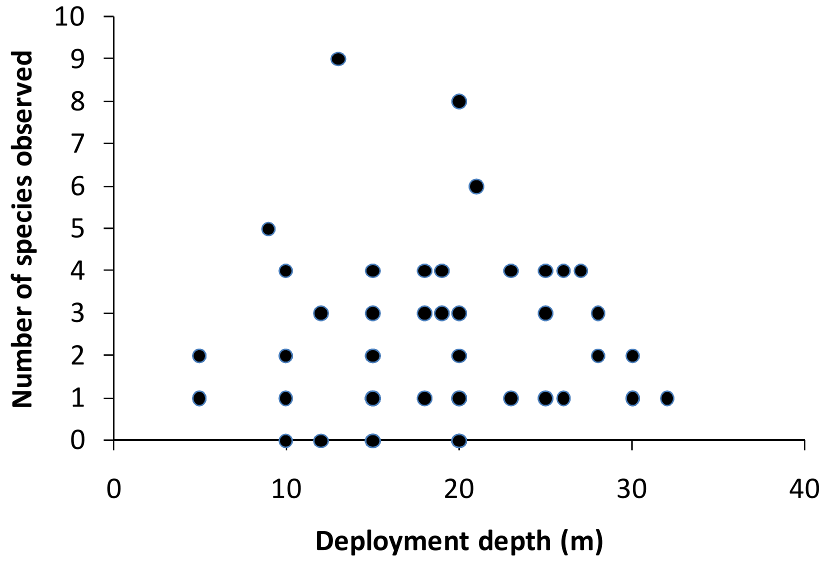

Figure 2.8 Number of species observed across the depth range surveyed. Each point is a single camera deployment, with all sites pooled.

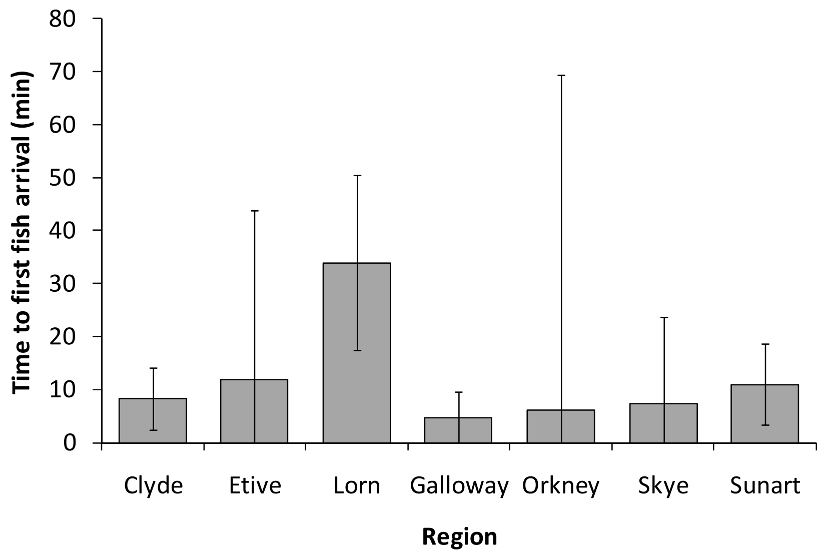

Figure 2.9 Mean time to first fish arrival at the baited camera system (±95% confidence limits) in the different study areas.

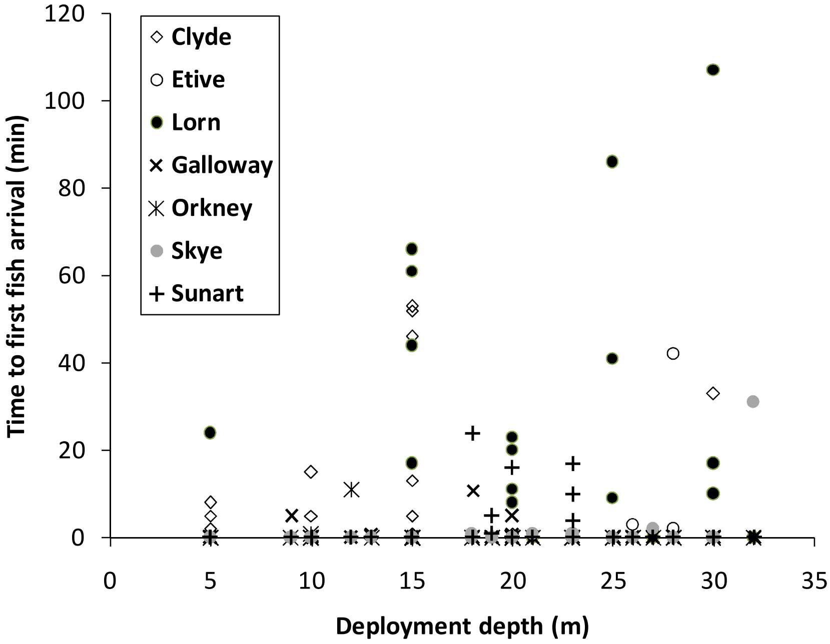

Figure 2.10 Time to first fish arrival at the baited camera system in relation to depth at which the camera was deployed.

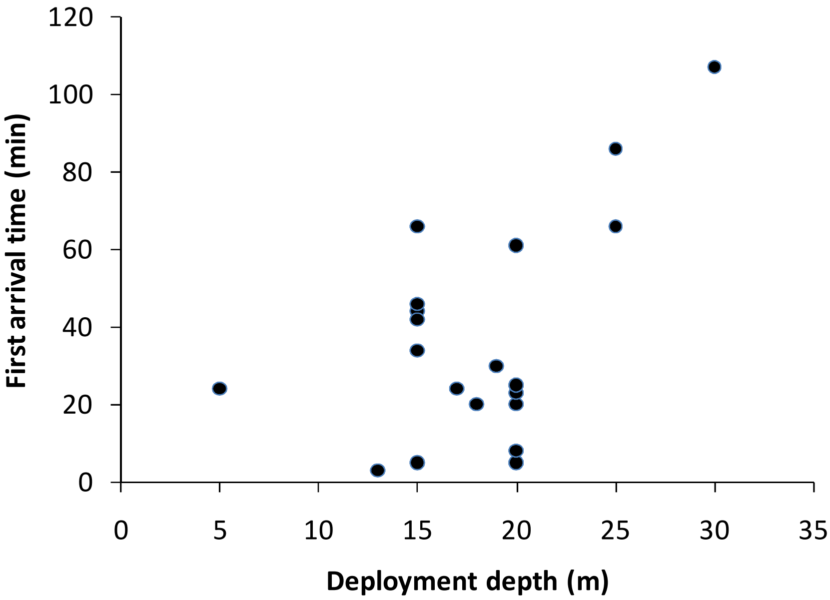

Figure 2.11 Time of first arrival at the baited camera system as a function of deployment depth for *Scyliorhinus canicula*.

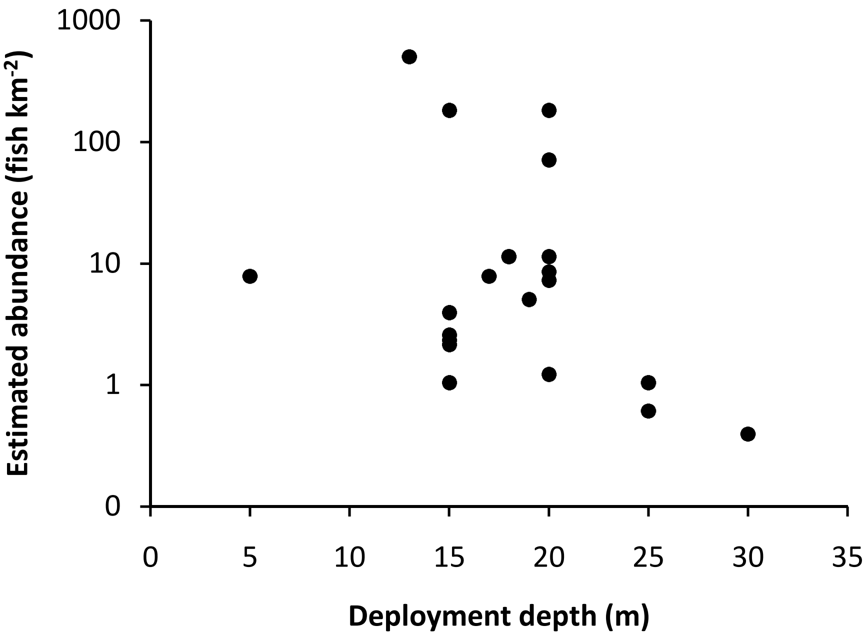

Figure 2.12 Estimated abundance of *Scyliorhinus canicula* based on first arrival time in relation to deployment depth.

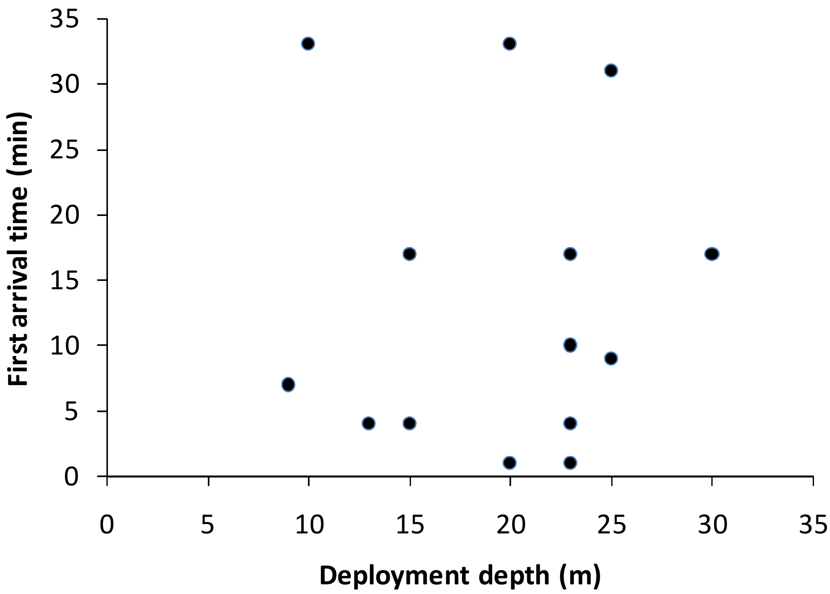

Figure 2.13 Time of first arrival at the baited camera system for goldsinny wrasse, *Ctenolabrus rupestris*, in relation to deployment depth.

2.3 Conclusions

A large number of baited underwater camera (BUC) deployments were made, over a wide spatial area and from a wide range of vessels. The BUC work demonstrated that the method was easy to apply, even where no specialist deck gear was available and was successful in detecting differences in the species richness and population density of different areas.

Comparisons of the BUC method with other survey types (diving and angling) follow the relevant sections.

3 Underwater Visual Census

3.1 Introduction

Underwater Visual Census (UVC) is a widely used survey method for marine animals, including fish. The method is particularly popular in tropical environments (e.g. English *et al*., 1997), and is widely used by professional and volunteer survey programmes for both routine monitoring of fish populations and scientific research (Magill & Sayer, 2002; Kamenos *et al*., 2004). Survey methods include belt transects, in which divers swim along a straight line of prescribed length and count fish seen within a set distance to either side, and stationary counts, in which divers remain in one place and count fish seen within a defined area over standardized periods of time. The size of the sampling units can be adjusted in relation to underwater visibility and other constraints. Both types of method are described in the UK Marine Monitoring Handbook (Davies *et al*., 2001) and Across Wales Diving Monitoring Project. UVC does not necessarily give a completely accurate indication of abundance and species composition of fish communities, since some fish will not be seen by divers and avoidance reactions of fish may differ by species and size (Chapman *et al.*, 1974; Sayer *et al*., 1996).

The aim of this part of the work was to survey sites both by baited underwater camera (BUC) and by UVC to compare results of the two methods.

3.2 Methods

Two sites were surveyed by UVC: Clashfarland Point and Skate Point, both on the Isle of Cumbrae. At each site, two divers descended to the sea bed and swam along a transect 50 m long at a speed of 10 m per minute and counted all fish seen within 2 m to either side of the transect, thus surveying an area of 100 m^2 in each transect. Transects were surveyed at depths of 5, 10, 15 and 20 m. The starting point of transects was located on the surface using transits on the shore. A 5 minute point survey was also conducted at a distance of 25 m along the 50 m transect, following the protocol described in the JNCC Marine Monitoring Handbook, 2001 (Davies *et al*. 2001). For each fish observed along the transect and observed in the point surveys, the species and the time of first observation were recorded.

3.3 Results

Twelve fish species were recorded in UVCs (Table 3.1). The number of species and number of individuals counted showed no obvious patterns in relation to depth at the survey sites (Fig. 3.1), though the species recorded varied somewhat with depth (which was also associated with changes in seabed type from rocky at 5 m to silty sand at 20 m).

Fewer individuals and fewer species were detected with the BUC at these sites (Fig. 3.2), such that it was not possible to establish a relationship between results from the two methods in terms of species richness or abundance.

Table 3.1 Species recorded in underwater visual censuses.

Common name	Latin name
Lesser spotted dog fish	*Scyliorhinus canicula*
Cuckoo wrasse	*Labrus mixtus*
Ballan wrasse	*Labrus bergylta*
Goldsinny wrasse	*Ctenolabrus rupestris*
Rock cook	*Centrolabrus exoletus*
Leopard spot goby	*Thorogobius ephippiatus*
Two spot goby	*Gobiusculus flavescens*
Common goby	*Pomatoschistus microps*
Sand goby	*Pomatoschistus minutus*
Common dragonet	*Callionymus lyra*
Plaice	*Pleuronectes platessa*
Dab	*Limanda limanda*

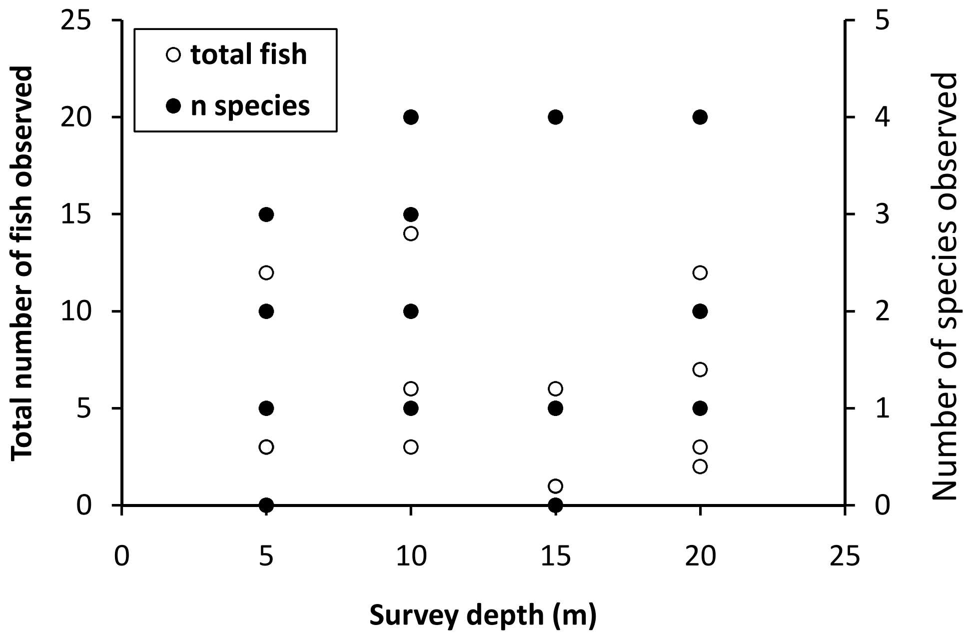

Figure 3.1 UVC data for Clashfarland Point and Skate Point, Isle of Cumbrae. Both sites pooled, across the depths surveyed. Open points are the total number of fish observed, filled points are the number of species observed.

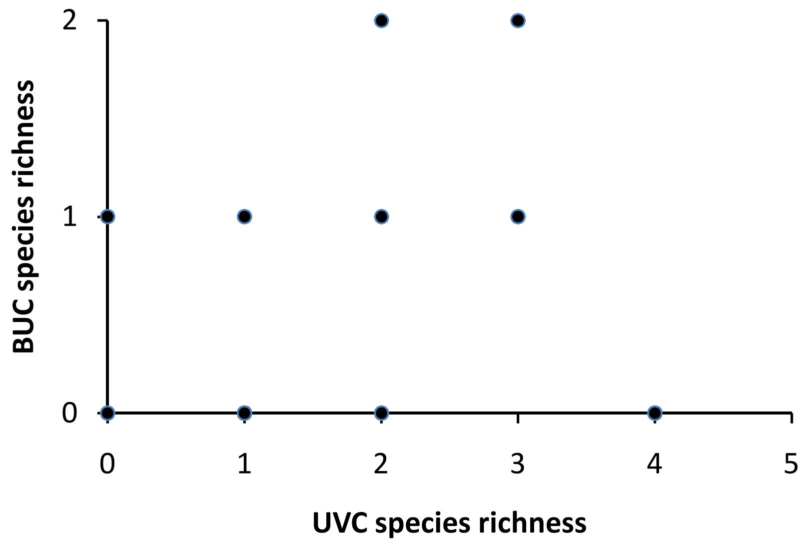

Figure 3.2 Species richness as observed by underwater visual census and baited underwater camera survey at Clashfarland Point and Skate Point, Isle of Cumbrae. Each data point represents one location where both a UVC and BUC survey was carried out.

3.4 Conclusions

The two UVC methods (transects and point counts) were successfully carried out in the conditions of current and visibility in the Firth of Clyde. However, the small number of UVCs carried out was a consequence of the greater complexity and time cost of carrying out this sort of work and the level of training and qualification required by the survey divers and diving supervisor. Nevertheless, these methods detected more species than the BUC deployments in the same locations, indicating that UVCs may provide a better representation of fish biodiversity. These surveys could be targeted at areas of particular interest, as part of a wider survey using less labour-intensive methods such as BUC.

4 Angling surveys

4.1 Introduction

The use of volunteer recreational sea anglers has the potential to provide data on the relative abundances of certain species of fish around Scotland. The Scottish Sea Angling Conservation Network administers collection of records from tagging events and angling competitions, which could be developed to provide indices of changes in stock abundance over time.

4.2 Methods

Pilot studies were conducted at Port Logan and Cairngaan, Dumfries and Galloway and in Loch Etive. Angling surveys were carried out by four anglers angling for 1 hour from a small power boat. Lines were baited 50% with Ragworm and 50% with mackerel (*Scomber scombrus*) ‘flappers’ to ensure that a range of species would be attracted. Baits were checked and replaced regularly to ensure that the supply of bait remained constant. The species and total number of fish caught and returned were recorded as well as the time that each individual was captured. BUC deployments were made in the same areas, allowing sufficient distance that the odour plume from the BUC bait should not have affected the angling results.

A randomized survey design was developed for anglers fishing in a major skate tagging event at Crinan in April 2010 (Appendix 1), but in the event the skate fishing was poor and insufficient anglers volunteered to participate in the survey.

4.3 Results

The species most commonly recorded in the pilot angling surveys were dogfish, ballan wrasse and pollack, followed by a range of other elasmobranch and teleost species (Table 4.1).

A larger number of species was observed by the BUCs, and the relative abundances of the species also differed (Table 4.2), presumably reflecting different catchabilities on hook and line.

Table. 4.1 Species recorded in angling surveys.

Common name	Species	Rank	Number of surveys species recorded
Lesser spotted dogfish	*Scyliorhinus canicula*	1	4
Ballan wrasse	*Labrus bergylta*	2	3
Pollack, lythe	*Pollachius pollachius*	3	3
Grey gurnard	*Eutrigla gurnardus*	4	2
Cod	*Gadus morhua*	5	2
Saithe, coley	*Pollachius virens*	6	2
Thornback ray	*Raja clavata*	7	2
Spurdog	*Squalus acanthias*	8	2
Cuckoo wrasse	*Labrus mixtus*	9	1
Haddock	*Melanogrammus aeglefinus*	10	1
Mackerel	*Scomber scomber*	11	1
Nursehound, bull huss	*Scyliorhinus stellaris*	12	1

Table 4.2 Species caught by angling, and observed by BUCs at Galloway sites during coordinated surveys. Bold type, underlining and double underlining are used to indicate where the top three species as caught by anglers appear in the BUC species list.

Species recorded by angling	No. caught	Species recorded by BUC	No. observed
Pollachius pollachius	34	*Centrolabrus exoletus*	24
Labrus bergylta	28	*Labrus mixtus*	9
Scyliorhinus canicula	10	***Scyliorhinus canicula***	8
Pollachius virens	2	*Trisopterus minutus*	8
Gadus morhua	1	*Merlangius merlangus*	6
Labrus mixtus	1	*Ctenolabrus rupestris*	5
Melanogrammus aeglefinus	1	***Labrus bergylta***	5
Scyliorhinus stellaris	1	***Pollachius pollachius***	5
		Crenilabrus melops	4
		Melanogrammus aeglefinus	4

Species recorded by angling	No. caught	Species recorded by BUC	No. observed
		Pollachius virens	3
		Gobiusculus flavescens	2
		Asptrigla cuculus	1
		Eutrigla gurnardus	1
		Gadus morhua	1
		Limanda limanda	1
		Scyliorhinus stellaris	1

4.4 Conclusions

A small number of pilot angling surveys were conducted. This relatively small number of surveys reflects the difficulty in recruiting recreational anglers into a standardized angling protocol, especially where this is not likely to maximise their catch rate. Two days of angling surveys required 8 person-days of labour. The BUC data was obtained by one scientist, equating to 2 person-days over the same period.

The Scottish Shark Tagging Programme records data on fishing effort and catches of certain species during organized events, but it is difficult to ensure that anglers provide zero returns, to allow unbiased calculation of catch per unit effort. Any future efforts to utilize recreational sea anglers to collect data useful to inshore fisheries management would probably need to include incentives, such as paying the expenses of their angling trip.

5 Fish bycatch in creel fisheries

At the suggestion of the SISP Steering Group, the potential for commercial creel fishing for crustaceans to provide information on changes in fish populations was investigated. This was done through a questionnaire survey of creel fishers and on-board recording of fish bycatch.

5.1 Questionnaire survey

A questionnaire was distributed to creel fishers through local fishers' representatives and local fishery offices. Some fishermen were interviewed during port visits. The questionnaire is reproduced in Appendix 2 and was designed to gather information about target species, fishing methods, fishing areas, fish species caught, and the frequency and seasonality of fish bycatch. An information sheet about the project was also circulated to creel fishers (Appendix 3). It was considered that it would not be possible to obtain accurate information on the actual quantities of fish caught, so questions were framed in terms of the approximate percentage of creels with fish and the months in which different species were regularly caught.

In addition to the paper version of the questionnaire, an on-line version was created and advertised for two weeks in the *Fishing News* and publicized through local coordinators of the Inshore Fisheries Groups. A prize draw was offered, with a prize of a £100 'One4All' gift card to encourage responses. The on-line version of the questionnaire can be viewed at http://www.gla.ac.uk/creel_q/.

Responses were received from 19 fishers, who could be placed into two broad categories: primarily crab and lobster fishers and primarily Norway lobster fishers (Table 5.1). Twelve respondents completed the paper questionnaire and seven completed the on-line version.

Table 5.1 Number of creel fishery questionnaire respondents by region and fishery.

Region	Crab & lobster	Norway lobster
West	1	1
Northwest	1	7
North	1	–
Orkney	4	–
Northeast	4	–
TOTAL	11	8

5.1.1 Questionnaire findings

All creel fishers responding to the questionnaire reported fish bycatch (Fig. 5.1). Most species were common to both types of crustacean fishery, but ‘rockling’ and ‘wrasse’ (species not specified) were reported only by crab/lobster fishers and hake and spurdog were reported only by Norway lobster fishers. There appears to be a high incidence of cod bycatch in both crab/lobster (73% of respondents) and Norway lobster (75%) creel fisheries, but it should be noted that these figures indicate the percentage of fishers reporting catching these species and not the actual quantities of fish caught. Ling, conger eel and dogfish also appear to be commonly caught in both fisheries, with fairly high incidences of whiting and poor cod or bib (*Trisopterus* spp.) in the Norway lobster creel fishery.

There was a difference between the fisheries in responses to the question ‘On average, approximately what percentage of your creels contain newly caught fish?’ (Fig. 5.2). The median value reported by crab and lobster fishers was 3.5% of creels with fish (with an inter-quartile range of 1.3% to 6.9%), while the equivalent value for Norway lobster fishers was 10% (IQR of 6.25% to 35%). This difference was statistically significant (Kruskal Wallis, H_1=4.05, $P<0.05$).

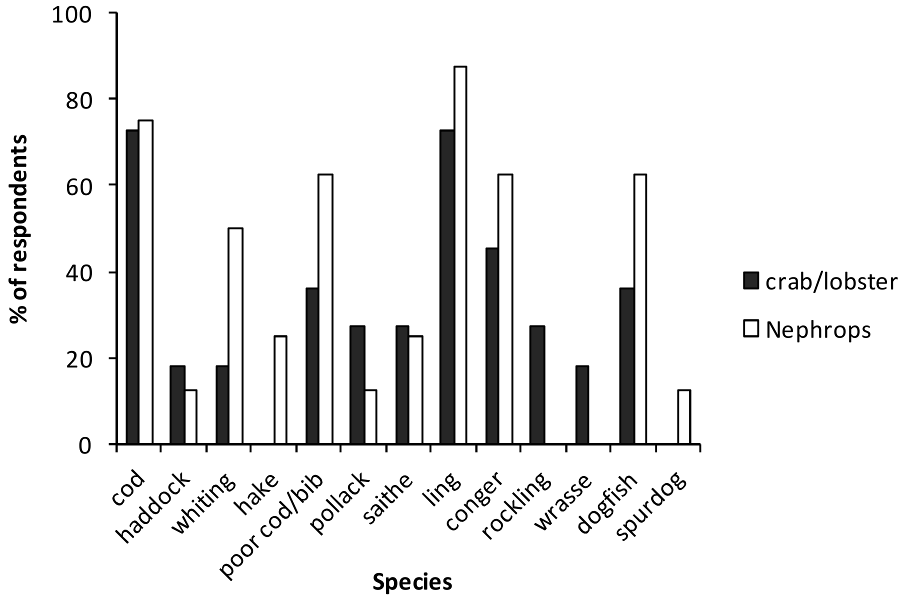

Figure 5.1 Percentage of respondents reporting fish bycatch by species and crustacean fishery type. Note that this does not indicate the quantities in which these fish species are caught.

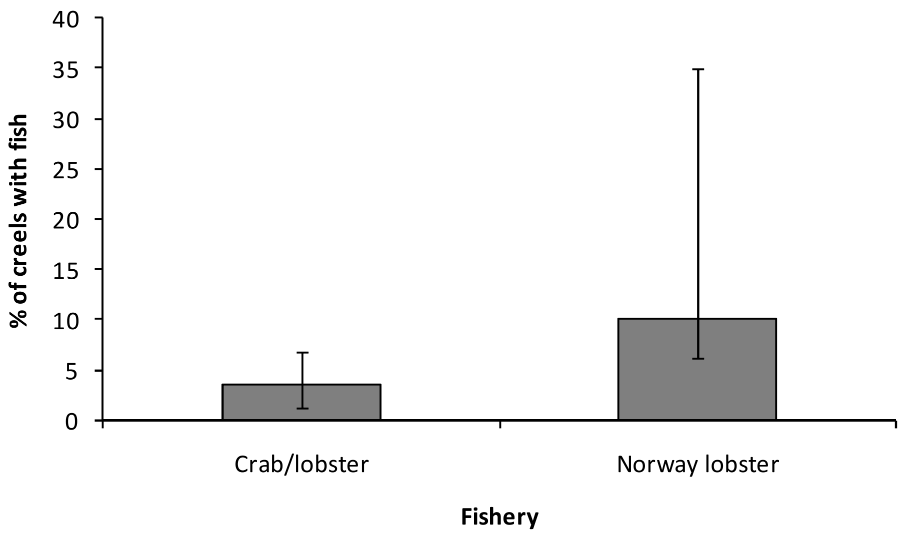

Figure 5.2 Percentage of creels with fish reported by creel fishers. The bars represent the median percentage; the error bars depict the interquartile range of reported values (encompassing the middle 50% of reported values).

5.1.2 Free text comments from questionnaires

Selected quotes from free text comments in questionnaire follow:

> "I catch SO few fish of commercial species that I can't see it as being of any significance, either conservation-wise or as a research tool. Or maybe there are just very few commercial fish left in this area." Norway lobster fisher, Skye.

“5% to 70% of creels with fish depending on area and time of year. Different areas will produce different amounts of fish depending on stage of tide (spring or neap tides) and weather conditions. Species will also vary with the tides.” Crab & lobster fisher, Orkney.

“Shallower ground more pout and codling. Deeper ground for ling. Catches of haddock almost disappeared in recent years. ... Codling this year has reappeared for the first time in 10/15 years. There are no haddock at all and very few whiting. Ling seems to be reasonably healthy. Hake are almost non-existent.” Norway lobster fisher, Wester Ross

“I would be willing to record fish catches if this would help. About 15 to 18 years ago we used to catch as much as 100 Cod in 1 day. My best day from 320 creels was 199 size Cod; this was September 1993. This was with fresh Mackerel as bait as I was fishing for Crab/Lobster.” Crab & lobster fisher, Angus.

[Which areas produce the greatest catches of fish?] “shallow ground in the winter. 15 to twenty fathoms. I catch large amounts of immature cod, often four or five in a creel.”

[Which areas produce the least?] “deep water 100 fathoms although we still get pout and spotted dog. See no fish normally when working on commonly used trawl tows.”

“I have reduced the size of eye that I use from 75mm to 55mm. This has dramatically reduced my by catch of fish. Especially the larger cod, ling and spotted dogfish. Still get lots of small cod and pout though. I think creels with an increased eye size from normal nephrops gear would probably be a very useful tool in monitoring fish stocks.” Norway lobster fisher, Wester Ross.

5.2 Catch sampling

Creel fishers were contacted through local fishery offices and port visits to ask if a scientist could carry out on-board catch sampling. Several fishers in different parts of Scotland were suspicious of the motives of the project and declined to cooperate. Ultimately, catch sampling was carried out on six vessels in Kintyre, Skye and Orkney in August 2010. A scientist went on board, noted the type of fishing gear in use, the bait used, and counted and measured all fish caught. The catch in 51 fleets of creels was examined, comprising 17 fleets fished for Norway lobsters, *Nephrops norvegicus*, 21 fleets fished primarily for crabs, *Cancer pagurus*, and 13 fleets fished primarily for lobsters, *Homarus gammarus*. The types of trap used and the depth and nature of the seabed reflected the primary target species (Table 5.2), but with individual variations among vessels. For example, one fisher in Orkney incorporated escape gaps into his crab creels; and a fisher in Kintyre used a mixture of ‘large’ (80 mm diameter) and ‘small’ (60 mm) hard eyes in his Norway lobster creels. The bait most commonly used bait was herring, but fishers also used salmon ‘frames’, horse mackerel and fish bycatch from their creels.

Table 5.2 Characteristics of creel fishing gear sampled.

Main target species	Number of fleets	Average no. creels per fleet	Creel types	Bait type	Average creel spacing (m)	Average depth (m)
Norway lobster	17	65	D-frame, side entrances, hard eyes	Salted herring, salmon frames	13	100
Brown crab	21	33	D-frame, side entrances, soft eyes 'Lobster pot'	Herring, scad, bycatch	26	59
Common lobster	13	33	D-frame, soft eye Parlour pot	Herring	22	9

5.2.1 Results

The catch in a total of 2219 creel-hauls was examined and 374 fish in 19 species were recorded (Figure 5.3). Poor cod (*Trisopterus minutus*) had the highest catch rate (19.1 fish per hundred creel-hauls), but were recorded only in Norway lobster creels. Other fishes were recorded at relatively low catch rates (<5 fish per hundred creel-hauls). The catch rate of cod (*Gadus morhua*) in crab creels was 3.8 fish per hundred creel-hauls and negligible in the other creel types. In total, 26 cod were recorded, ranging in length from 23 cm to 50 cm (mean length 31 cm). Catch rates of other commercial species (whiting, haddock, ling, dab) were less than 2 fish per hundred creel-hauls.

Some species were taken in more than one creel type. For example, lesser spotted dogfish (*Scyliorhinus canicula*) and conger eel (*Conger conger*) were taken by creels set for all three crustacean target species, though with highest catch rates in crab creels. Differences in species composition of fish bycatch among creel types reflected the ground types and depths being fished, with species typical of harder ground (e.g. ling and wrasses) more common in crab and lobster creels, for example. There was a significant difference in species composition of fish bycatch among the three types of fishing (Fig. 5.4, analysis of similarities with fleets nested within vessels, R=0.818, P=0.02).

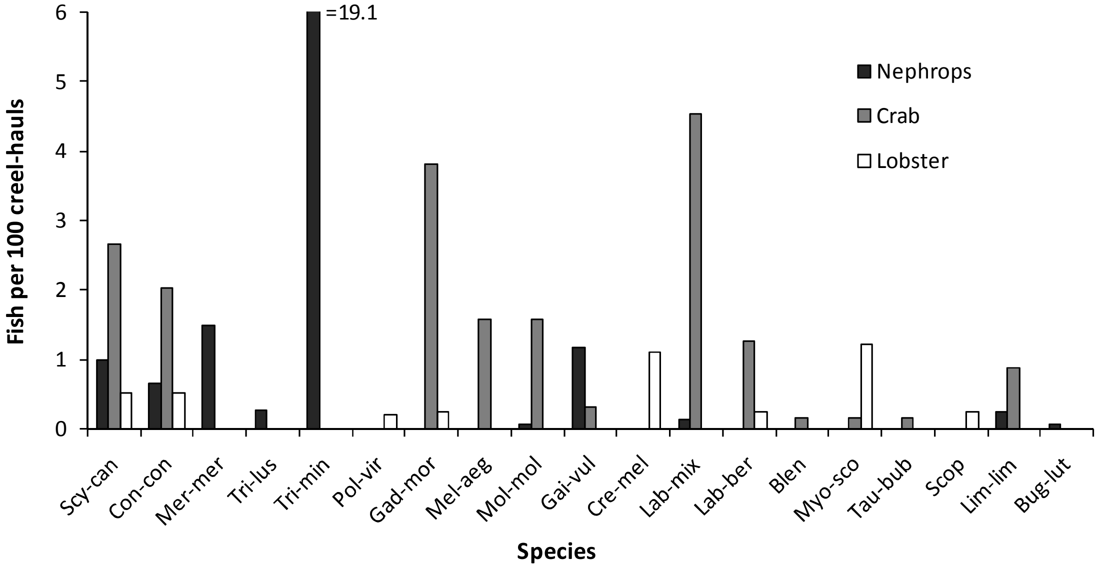

Figure 5.3 The catch per unit effort (CPUE) of fish caught in creels fished primarily for Norway lobster, crab or lobster. CPUE has been expressed as the number of fish per 100 creel-hauls. Note that the CPUE of poor cod, *Trisopterus minutus*, in *Nephrops* creels (19.1 fish per hundred creels) exceeds the scale of the graph. A key to the abbreviated species codes is given in Table 5.3.

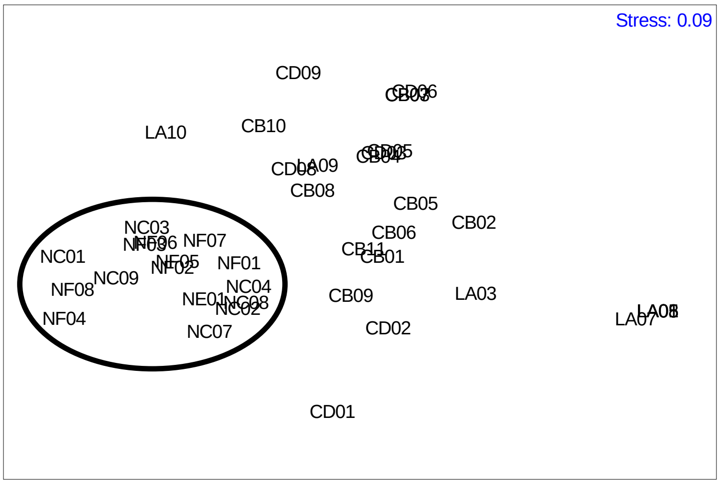

Figure 5.4 Non-metric Multidimensional Scaling plot of fleets in relation to their similarity of fish bycatch species composition. More-similar fleets are placed closer together. Fleets are coded by two letters and a number. The first letter indicates the main target species: N (Norway lobster), C (brown crab), L (lobster). The second letter (A–F) denotes different vessels and the number denotes different fleets. Note that fleets of Norway lobster creels cluster together in the left of the graph (surrounded by an ellipse). Fleets of crab creels form a more diffuse cluster towards the right, reflecting greater variability in species composition. This analysis is based on the Bray-Curtis similarity index calculated on the square-root transformed CPUE of each species in each fleet.

Table 5.3 Fish species names and abbreviated codes used in graphs.

Common name	**Family**	**Latin name**	**Code**
Lesser-spotted dogfish	Scyliorhinidae	*Scylionrhinus canicula*	Scy-can
Spurdog	Squaloidae	*Squalus acanthias*	Squ-aca
Conger eel	Congridae	*Conger conger*	Con-con
Whiting	Gadidae	*Merlangius merlangus*	Mer-mer
Bib	Gadidae	*Trisopterus luscus*	Tri-lus
Poor cod	Gadidae	*Trisopterus minutus*	Tri-min
Pollack	Gadidae	*Pollachius pollachius*	Pol-pol
Saithe	Gadidae	*Pollachius virens*	Pol-vir
Cod	Gadidae	*Gadus morhua*	Gad-mor
Haddock	Gadidae	*Melanogrammus aeglefinus*	Mel-aeg
Hake	Gadidae	*Merluccius merluccius*	Mer-mer
Ling	Gadidae	*Molva molva*	Mol-mol
Shore rockling	Gadidae	*Gaidropsarus mediterraneus*	Gai-med
Three-bearded rockling	Gadidae	*Gaidropsarus vulgaris*	Gai-vul
Five-bearded rockling	Gadidae	*Ciliata mustela*	Cil-mus
Corkwing wrasse	Labridae	*Crenilabrus melops*	Cre-mel
Goldsinny wrasse	Labridae	*Ctenolabrus rupestris*	Cte-rup
Cuckoo wrasse	Labridae	*Labrus mixtus*	Lab-mix
Ballan wrasse	Labridae	*Labrus bergylta*	Lab-ber
Unidentified wrasse	Labridae	Labridae	Labr
Dragonet	Callionymidae	*Callionymus lyra*	Cal-lyr
Tompot blenny	Blenniidae	*Parablennius gattorugine*	Par-gat
Unidentified blenny	Blenniidae	Blenniidae	Blen
Butterfish	Pholidae	*Pholis gunnellus*	Pho-gun
Bull-rout	Cottidae	*Myoxocephalus scorpius*	Myo-sco
Long-spined sea scorpion	Cottidae	*Taurulus bubalis*	Tau-bub
Fifteen-spine stickleback	Gasterosteidae	*Spinachi spinachia*	Spi-spi
Unidentified topknot	Scopthalmidae	Scophthalmidae	Scop
Dab	Pleuronectidae	*Limanda limanda*	Lim-lim
Solenette	Soleidae	*Buglossidium luteum*	Bug-lut
Unidentified fish	Other	Other	Other

5.2.2 Conclusions

A range of fish species are taken as bycatch in traps set for crustaceans. The present results suggest that the catch rates of commercial fish species are probably too low for creeling to be a useful way of monitoring fish stocks, but it should be borne in mind that these samples were taken at one time of year only (late August). To fully assess the potential of creel fisheries to provide useful information on fish populations, it would be desirable to monitor bycatch throughout the year at a range of locations, either by scientific sampling, or by a logbook scheme. If this was to be done, the present results suggest that with regard to fish species of commercial importance, future effort might best be focussed on the crab fishery. Year-round sampling was beyond the resources of the present study.

There were differences in fish bycatch composition between fleets targeting different crustacean species. These differences are likely to be due to a combination of the bottom type, depth and trap design, but may also reflect the geographical distance between the study areas, since the crab fisheries sampled were mainly on the north coast and in Orkney, whereas the Norway lobster creel fisheries were primarily on the west coast. Experiments using similar gear in the same area would be necessary to distinguish the effects of different factors.

5.3 Trap comparison

The potential for two types of baited trap designed to catch crustaceans to sample nearshore fishes was assessed in a fishing experiment conducted at three sites around the Isles of Cumbrae in June 2010. The two trap types tested were standard Norway lobster creels and replica Roscoff traps designed for catching the common prawn or ‘cameroon’, *Palaemon serratus*. The Norway lobster creels had a D-shaped frame 550 mm long, 400 mm wide and 320 mm high, with 20 mm mesh and 80 mm eye diameter. The Roscoff traps were cylindrical (650 × 350 mm), made of plastic mesh (10 mm apertures), with conical entrances at each end (50 mm eye) (Fig. 5.5). Bait was held in an integral cylindrical mesh tube.

Figure 5.5 Photograph of a replica Roscoff creel of length 650 mm and height 350 mm, with 10 mm apertures and a 50 mm eye diameter.

Three fleets of 16 traps were made up with eight Norway lobster creels alternating with eight Roscoff traps. The traps were attached by a 2 m ‘dropper’ line to a sinking fleet line at 15 m intervals. The Roscoff traps were not weighted, other than by the fleet line, and tended to float off the bottom. Both types of trap were baited with equal quantities of frozen herring, thawed before use.

The fleets were fished three times at each of three depths (5 m, 15 m and 25 m) at three sites (Clashfarland Point 55º 45.9′ N 4º 53.6′ W, Farland Point 55º 44.9′ N 4º 54.9′ W and Castle Bay 55º 43.4′ N 4º 56.3′ W) (27 fleet deployments, 216 hauls of each type of trap, in total).

5.3.1 Results

Sixteen species of fish were caught, 13 species in Norway lobster creels and 12 in Roscoff traps. Only three species of potential commercial interest were recorded: lesser spotted dogfish, cod and dab. The two species with the highest catch per unit effort were shore rockling, *Gaidropsarus mediterraneus*, and cod, *Gadus morhua*, with higher catch rates in Roscoff traps than Norway lobster creels, especially for cod (Fig. 5.6).

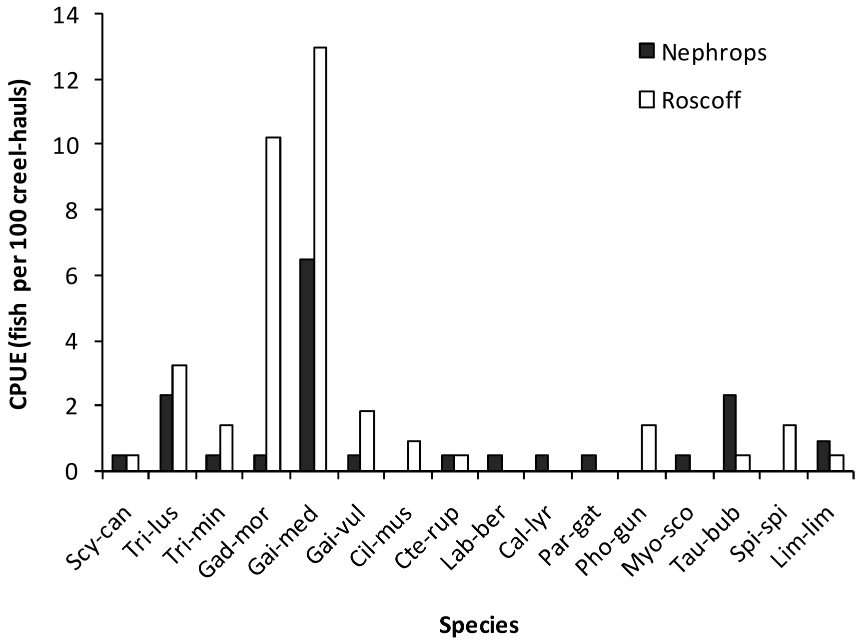

Figure 5.6 Catch per unit effort (fish per 100 creel-hauls) of fish in Norway lobster (labelled 'Nephrops') creels or Roscoff traps, Isles of Cumbrae, June 2010. Each bar represents the average of 216 creel-hauls. A key to the abbreviated species codes is given in Table 5.3.

In total, 23 cod were caught (1 in a Norway lobster creel and 22 in Roscoff traps). Most of the cod were juveniles of length 50–60 mm, except for three larger specimens: 43 cm caught in a Norway lobster creel, and 18 cm and 21 cm, respectively, caught in a Roscoff trap. Figure 5.7 indicates a degree of variation in cod abundance in relation to depth and/or seabed type at these sites.

5.3.2 Conclusions

Differences in catch rates between the two creel types mainly reflect differences in their design, since they were fished at the same time in the same area with the same bait. The entrances (50 mm) and mesh size (10 mm) of Roscoff traps were smaller than those on the Norway lobster creels (80 mm and 20 mm, respectively), so would be expected to exclude larger fish and retain smaller fish. The greater catch rate of juvenile cod in Roscoff traps is probably due to this. Roscoff traps tended to float off the bottom, move around and were darker inside and these characteristics may also have affected their species and size selectivity.

The present results suggest that Roscoff traps or a similar design may be a useful method for surveying juvenile cod in complex habitat in nearshore waters. Unlike netting methods, such as fyke nets, fish do not become entangled in mesh and so can be captured and released in good condition. Fleets of Roscoff traps could be deployed and hauled from chartered creel vessels. Further investigation of the size selectivity of Roscoff traps for species of interest would be desirable.

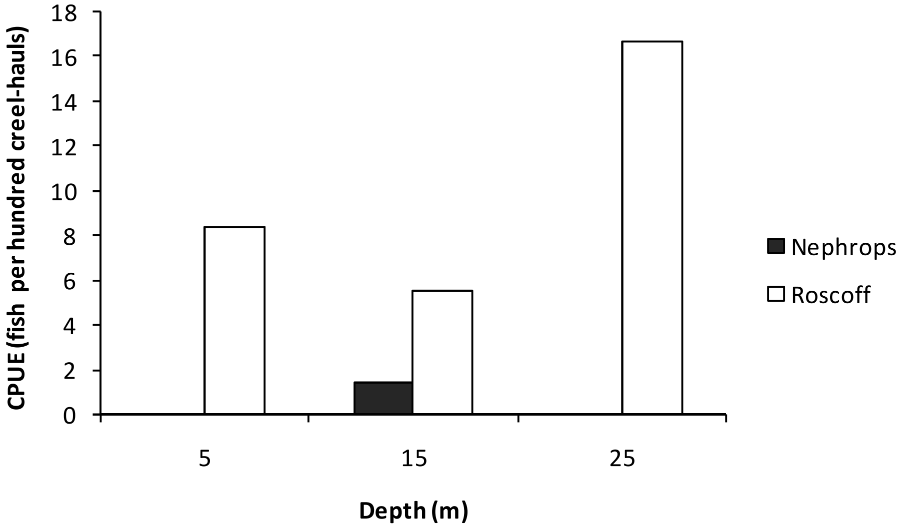

Figure 5.7 Catch per unit effort of juvenile cod, *Gadus morhua*, at three depths in Norway lobster creels and Roscoff traps, Isles of Cumbrae, June 2010. Bars represent the average of 72 creel hauls.

6 Electronic tagging studies

6.1 Spurdog movements in Loch Etive

A study was undertaken to monitor movements of spurdog in Loch Etive in October 2010. The aim was to obtain data on the movements of spurdog to assess whether they are resident in Loch Etive.

6.2 Methods

Electronic Star-Oddi centi data storage tags (DSTs) were deployed on 10 spurdog (*Squalus acantias*) in Loch Etive (Fig. 6.1) on the west coast of Scotland.

An inshore vessel, the ‘Laura Dawn’, was chartered to capture spurdog using rod and line and barbless hooks, to ensure they could be easily and quickly removed. Fish were anaesthetised in a seawater bath containing MS222 in a concentration of 1 g per 10 litres of seawater, then the length, girth, weight and sex was recorded (Table 6.1).

Electronic Star-Oddi centi data storage tags (DSTs) were deployed in 10 spurdogs of 55 cm length or greater. Tags were programmed to record pressure and temperature every 5 minutes (n=5) or 10 minutes (n=5). The DSTs were attached externally using two stainless steel wire ‘Carling’ tags passed through the base of the dorsal fin. A plastic washer prevented the DST from touching the skin of the fish on one side and another on the other side kept the tag in place with a twist to the wire (Fig. 6.2).

After tagging, the fish were placed in a recovery tank of seawater. When they had regained their balance, they were placed in the sea but a hold was maintained around their tail to ensure they were able to swim before being released. Upon showing signs of activity they were released. The majority of fish swam straight down.

Figure 6.1 Loch Etive on the west coast of Scotland with the approximate tagging location indicated by a green circle.

In addition to the DST-tagged fish, 12 acoustic tags were also inserted into spurdog as part of a separate project. Full details of this will be available soon. All tagging was authorised under a UK Home Office licence.

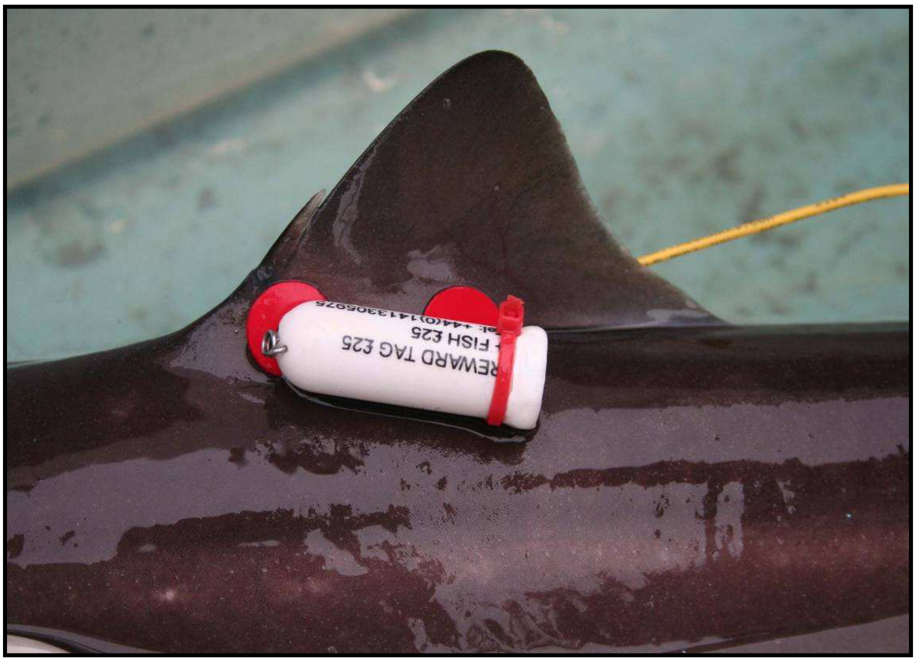

Figure 6.2 showing the location of the Star-Oddi centi data storage tags on the fish.

Figure 6.3 showing the size of tags in relation to the fish. In this instance, the fish is being placed in the recovery tank.

Table 6.1 Details of spurdog tagged with data storage tags (DST) in Loch Etive on 26 October 2010.

Recording interval	**DST number**	**External tag**	**Lat. (N)**	**Long. (W)**	**Depth (m)**	**Sex**	**Length (cm)**	**Width (cm)**	**Weight (kg)**	**Time caught**
5 min	5172	6019	56º 27.414′	5º 17.778′	35	F	80.5	27	2.66	10:15
	5162	2194	56º 27.414′	5º 17.778′	35	F	82.5	25	3.18	10:38
	5167	6020	56º 27.414′	5º 17.778′	35	F	55	17.5	1.26	10:35
	5166	6022	56º 27.484′	5º 17.723′	25.5	F	63	20.5	1.36	14:26
	5159	6074	56º 27.355′	5º 17.578′	39	F	71	23	2.36	13:05
10 min	5171	6070	56º 27.483′	5º 17.722′	25.5	F	63	23	1.80	14:09
	5183	6024	56º 27.484′	5º 17.723′	25.5	M	64.5	24	1.92	14:15
	5184	6098	56º 27.484′	5º 17.725′	25.4	F	64	22	1.82	15:00
	5181	6067	56º 27.484′	5º 17.725′	25.4	M	62	17	1.24	14:41
	5177	6011	56º 27.355′	5º 17.578′	39	F	72	22	2.08	13:19

6.3 Results

To date (28 November 2010), one data storage tag has been returned. The period at liberty was only 5 days (26–30 October). Nevertheless, some interesting patterns are revealed with the spurdog coming very shallow (5 m) during the night (Fig. 6.4).

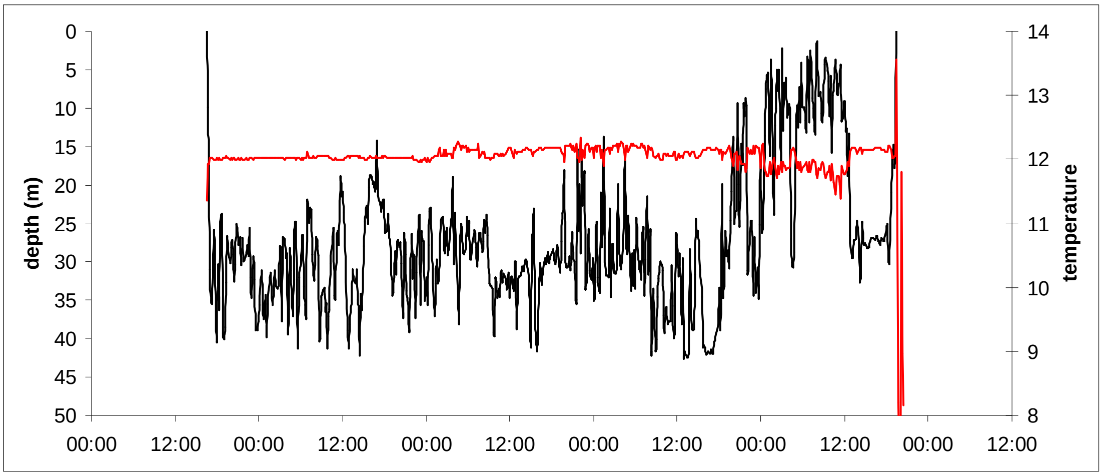

Figure 6.4. Data from DST 5184. The black line is depth (m) and the red line is temperature (ºC).

6.4 Conclusion

It is too early to draw any conclusions, other than the tagging was successful and it would seem there is a good chance to get tags returned in the future. The small amount of data recovered gives an indication of type of insights we can expect this study to yield in due course.

7 General conclusions and recommendations

This project aimed to develop and test novel methods for surveying nearshore fish populations in Scotland. The main methods investigated were baited underwater cameras (BUC), fish traps, underwater visual census, angling surveys and fish bycatch from creel fisheries.

7.1 Baited underwater cameras

A baited underwater camera (BUC) system was developed and deployed in various locations from research vessels, creel fishing vessels and small boats. The system was lightweight and could be deployed from small vessels by two persons (i.e. a boatman and a scientist or technician). The two relative indices of abundance derived from the camera records, time to first arrival (TFA) and the maximum number of individuals in view at any time (MaxN) showed variation among sites, suggestive of differences in fish abundance. TFA is relatively quick to determine, since the sequence of photographs needs to be examined only until the first appearance of an individual of the species of interest. Determining MaxN involves examining all of the photographs from a given deployment (1 hour deployment period, 120 photographs, in the present study), but being based on more information, may provide a less variable measure. Converting these relative measures to estimates of absolute population density requires knowledge of bait odour dispersal patterns, fish responsiveness and swimming speed (Farnsworth *et al*., 2007). An example with simplified assumptions for dogfish (*Scyliorhinus canicula*) has been given in section 2.2.

BUC shows great potential as a cost-effective survey method, able to show relative differences in abundance between areas. It is likely that it would also be effective in detecting temporal trends, though this was outside the scope of the present project. When compared within a single area, BUC detected more species than angling or fish traps, but less than visual transects by SCUBA divers. BUCs do not detect all species, and where detailed biodiversity data are required BUCs should be supplemented by diver surveys. BUCs are probably a better method for wide-area surveys, allowing the more labour intensive diving surveys to be targeted where they are most valuable.

Given the success of BUC systems, we recommend that a pilot survey of an area of interest is carried out using this method. The pilot survey area could be an existing or proposed marine protected area for example.

The camera systems used in the present study had a depth rating of 60 m and were generally used in depths shallower than 40 m. Some of the species of interest to recreational sea anglers occur in greater depths, such as skate (*Dipturus batis*) in depths of over 100 m in the Sound of Jura. We recommend that a camera system with a greater depth rating (e.g. 200 m) should be developed to extend the range of habitats and species that can be surveyed.

7.2 Fish traps

Fish traps were tested in the form of Norwegian collapsible cod traps, Roscoff traps and *Nephrops* creels. Each of these trap designs caught fish, although the size and species of fish varied with trap design. The size of trap entrance and mesh size will clearly affect the size distribution and species composition of fish caught, as will the habitat and depth in which the traps are deployed. The Roscoff traps appeared to be suitable for sampling juvenile cod in nearshore complex habitat, while the collapsible cod traps were suitable for larger fish.

Further work on the cod traps with and without otter guards would be desirable to test the effect on fish selectivity of this modification.

Only three collapsible cod traps were used during this study, but they are designed to take up little deck space and can be fished in fleets from inshore vessels (Furevik & Løkkeborg, 1994). Compared with BUC equipment they are relatively cheap (*ca* £75 *versus ca* £2000), but given the longer deployment periods (e.g. overnight), fewer replicates are possible for a given number of units within a given survey period. Removing and processing trap catches also takes up more time in the field than retrieving digital photographs from a BUC system. On the other hand, trapping has the advantage of allowing the fish to be measured, sampled or tagged and so could be very useful in some situations.

Given the interest of inshore fishery managers in populations of juvenile gadoids and the success of fleets of Roscoff traps in sampling them, we recommend that this method should be used in conjunction with the BUC survey recommended above.

7.3 Creel fish bycatch

Creel fisheries were surveyed by questionnaire and by on-board catch sampling. The present results suggest that the catch rates of commercial fish species are probably too low for creeling to be a useful way of monitoring fish stocks, but it should be borne in mind that these samples were taken at one time of year only (late August). Responses from creelers in the questionnaire survey indicated that there is considerable seasonal variation in bycatch of some species in some areas. It was beyond the scope of the present study to carry out year-round sampling. If the potential of creel fishing to monitor fish populations is to be investigated further, we recommend a combination of monthly sampling of Norway lobster and crab creel fisheries throughout the year and a logbook scheme for willing fishers to record their fish bycatch in a standardized form.

7.4 Rod-and-line surveys

A small-scale pilot study in Galloway demonstrated the potential for rod-and-line surveys to generate useful information on the abundance of certain fishes. However, we were unsuccessful in recruiting volunteer recreational sea anglers to participate in larger surveys at organised angling events. Anglers were understandably unwilling to be directed where to fish in a randomized survey design, even for part of the available time. Nevertheless, angling may be the best method for surveying certain threatened species, particularly the larger elasmobranchs, such as skate (*Dipturus batis*), tope (*Galeorhinus galeus*) and spurdog (*Squalus acanthias*). Valuable information on catches and tagging is collected by the Scottish Sea Angling Conservation Network and the Scottish Shark Tagging Project. If participants could be encouraged to complete nil returns, the data would be even more useful, because measures of catch-per-unit effort could be more readily derived. We recommend support for ongoing work to analyse the catch and mark-recapture data sets to obtain information on temporal changes in stock status and on fish movements. We also recommend that fishery scientists should continue to engage with the recreational sea-angling community to develop practical rod-and-line survey methods that volunteers – possibly selected groups of expert anglers – are able to participate in.

7.5 Underwater Visual Census (UVC)

Surveys by SCUBA divers were undertaken at two locations in the Clyde. The divers were able to carry out the method successfully, but the work was constrained by logistic and legal requirements. The UVCs detected more fish species than BUCs deployed at the same locations, and so are probably a better means of assessing biodiversity, but at a greater time and staff cost. We recommend that UVC methods such as transects and point counts continue to be used for fish surveys. UVCs are probably best used in a targeted way, following larger-scale surveys using BUCs and traps.

7.6 Comparison of methods

In assessing the reliability of estimates from different survey methods, it is problematic that the true abundance of fish in any area is unknowable. Since each survey method has its own biases, no one method provides the ‘correct’ answer. Direct comparison is also hindered by the different temporal and spatial scales of sampling by different methods and the fact that they are not all suited to the same habitats and conditions. It had been our intention to apply the same methods in the same area at nearly the same time to compare the estimates obtained and their variability, but the apparently low numbers of fish at most sites investigated made it difficult to establish correlations between the estimates by different methods. The sites in Galloway appeared to have the greatest fish abundance, but these were visited towards the end of the project period and only two methods (BUC and angling) were applied there. We recommend further comparison of BUC, fish traps and angling at sites with greater fish abundance, such as in Galloway.

7.7 Electronic tagging

An aim of the project was to investigate movements of spurdog (*Squalus acanthias*) through electronic tagging. Spurdog have been successfully sampled by rod-and-line in Loch Etive and tagged with data storage tags recording depth and water temperature. To date, only one tag has been recovered, but this has provided an indication of the type of information that will become available about spurdog movements. We recommend continued support for the collection and analysis of these data.

7.8 Industry-Science partnership

This project has established a partnership between representatives of the recreational sea-angling community and fishery and conservation scientists. Continued engagement will lead to improved scientific appreciation of the characteristics of recreational sea angling and its potential to generate information useful to management, and to greater awareness among the angling community of the type of scientific information needed by managers. We recommend that Marine Scotland continues to support liaison between anglers and scientists. This might take the form of regular meetings between representatives of SSACN and Marine Scotland.

7.9 Summary of conclusions

1. Baited camera systems appear to be a useful method for determining relative differences in fish abundance and species richness between areas. The method used in this project could be applied now, but some extra development work to increase the depth range and refine the methods for calculating absolute abundances would be worthwhile.

2. Underwater visual census methods appear to be effective, but due to their greater time and logistic costs would be best used in a targeted manner.

3. Traps do catch fish, and some designs could be effective survey tools, especially as they allow the sampling or tagging of the catch.

4. Creel fisheries may provide useful information on changes in populations of certain fish species, but further investigation throughout the year in crab and Norway lobster fisheries is required to assess this.

5. Teams of anglers, and the angling community in general, provide a potential source of data on fish distribution, but more work is required in recruiting and motivating volunteers to fish in a truly systematic way (i.e. sacrificing maximum catch rates by fishing in random locations). This will require ongoing engagement between recreational sea anglers and fishery scientists.

7.10 Summary of recommendations

1. To improve our understanding of baited methods of surveying fish and to develop improved estimates of abundance, modelling studies of bait odour dispersal and fish responses are required, building on previous work in this area.

2. Further trials of BUC at different sites and under different conditions are required to assess the degree of variability in the different types of abundance index that can be derived.

3. Further work to compare different survey methods is required at sites with greater fish abundance, e.g. at sites around the Galloway peninsula.

4. A BUC system with greater depth limit (e.g. 200 m) should be developed to extend the range of habitats in which it can be used to include other species of interest.

5. Further work is required to assess the size and species selectivity of different designs of fish trap.

6. An intensive pilot survey of an area of interest, such as an actual or proposed marine protected area, by BUC and fish traps would provide a good test of the ability of these methods to generate data of use to inshore fishery managers and conservation interests.

7. Seasonal sampling of fish bycatch in Norway lobster and crab creel fisheries is desirable to further assess the potential for creel fisheries to be used to monitor fish populations.

8. Ongoing analysis of recreational sea-angling catch and tagging records should be encouraged and supported by Marine Scotland.

9. There should be continued engagement between recreational sea-anglers and fishery scientists in Marine Scotland and universities.

8 Acknowledgements

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Appendix 1. Plan for angling survey in northern Sound of Jura, April 2010

Anglers participating in the skate tagging weekend on 17–18 April 2010 are requested to assist in research on new methods of surveying inshore fish populations. We would like to investigate the possibility of using standardized angling surveys to provide information on changes in fish abundance. We therefore hope to incorporate a trial of an angling survey during the skate tagging event at Crinan, while trying to cause minimum disruption to anglers' sport.

It is understood that all boats will record details of their fishing activity for both days on Scottish Shark Tagging Programme (SSTP) record cards. This in itself is a good source of information. In addition, those who are willing to participate in a standardized angling survey are requested to fish at an allocated position (mark) for a 2-hour period during the phase of the tide that skate are expected to be feeding (when the tide is running west or north). It is suggested that convenient periods will be from 10:00 to 12:00 on Saturday and from 10:30 to 12:30 on Sunday. These periods are during the second half of the ebb tide. Other periods could be chosen by the event coordinator, Ian Burrett, **but they must be the same for all participating boats** and should be at the same stage in the tidal cycle on different days. A period of 2 hours has been chosen so as not to ask anglers to fish (potentially unproductively) in the same place all day.

As far as possible, during the survey periods, all participating anglers should fish in the same way, using the same type of bait and tackle. Non-participating boats are requested to keep clear of survey boats fishing on allocated marks.

Catches (including zero catches) during survey periods must be **recorded separately from catches made at other times in the weekend**. Skippers of participating boats are requested to complete SSTP record cards **separately** for the standardized fishing periods and to **mark the cards clearly with "SISP survey"**. The duration of fishing should be recorded carefully, subtracting any non-fishing time, for example when playing fish or dealing with snags and tangles. The actual time fishing for each rod is likely to be less than the 2 hours of the survey period.

SSTP Record cards for the whole day's fishing should be completed as normal and should include catches made during the survey period. This means that fish caught during the 2-hour survey period will be recorded on two cards. To avoid double counting of fish it is vital that the survey cards are marked clearly as indicated above.

It is important that **zero catches** during the survey period are recorded. If no fish were caught by a boat during a 2-hour survey period, the details in the upper part of the SSTP card for the survey should still be completed and the fish catch section marked clearly with "no fish caught".

If some anglers on the boat fished with more than one rod at the same time, it would be helpful to note on the card the number of anglers, as well as the number of rods.

Tides at Carsaig Bay (BST)

Sat 17 Apr	Sun 18 Apr
07:26 1.7 m	07:58 1.6 m
13:32 0.3 m	14:09 0.4 m
19:31 1.7 m	20:05 1.7 m

Survey positions

The positions listed below should be allocated in sequence to boats (with GPS) for each day by the event coordinator. **Each position should be allocated only once.** It is anticipated that there may be six to eight participating boats fishing over two days, in which case up to sixteen positions would be allocated. A surplus of positions has been provided in case there are more boats or some positions are impossible to fish for some reason. Boats should stay on their allocated mark during the survey period, if safe to do so. **Lack of fish must not be used as a reason to change position during the 2-hour survey period.** The positions have been chosen to be at least 100 metres apart and spread randomly throughout a survey area bounded by the 100 metre depth contour off Loch Crinan, stretching to the southwest for approximately 2 nautical miles.

Station	Latitude	Longitude	Boat/skipper	Date fished
1	56°05.75' N	5°36.54' W		
2	56°05.22' N	5°36.64' W		
3	56°05.03' N	5°36.83' W		
4	56°05.42' N	5°36.88' W		
5	56°05.33' N	5°36.97' W		
6	56°05.33' N	5°36.97' W		
7	56°05.22' N	5°37.42' W		
8	56°06.27' N	5°35.45' W		
9	56°06.05' N	5°35.90' W		
10	56°06.18' N	5°35.54' W		
11	56°06.16' N	5°35.67' W		
12	56°06.81' N	5°35.56' W		
13	56°06.08' N	5°36.20' W		
14	56°06.58' N	5°35.24' W		
15	56°05.96' N	5°35.65' W		
16	56°05.66' N	5°35.86' W		
17	56°05.63' N	5°36.55' W		
18	56°05.81' N	5°36.71' W		
19	56°05.93' N	5°36.13' W		
20	56°06.29' N	5°35.88' W		
21	56°05.58' N	5°36.39' W		
22	56°05.87' N	5°35.75' W		
23	56°05.41' N	5°37.23' W		
24	56°05.27' N	5°36.59' W		
25	56°06.03' N	5°36.03' W		
26	56°05.09' N	5°37.00' W		
27	56°05.27' N	5°36.81' W		
28	56°06.48' N	5°35.90' W		
29	56°05.13' N	5°36.95' W		
30	56°05.64' N	5°36.21' W		
31	56°05.20' N	5°37.33' W		
32	56°05.16' N	5°37.04' W		
33	56°06.07' N	5°35.99' W		

Appendix 2. Creel fishery questionnaire

(Please see also the on-line version of the questionnaire at http://www.gla.ac.uk/creel_q/.)

This questionnaire is designed to gather information on the amount of fish caught in pots and creels and to determine whether this could provide information about the state of inshore fish populations. This questionnaire is being circulated to pot and creel fishermen throughout Scotland to allow us to assess patterns in fish catches around the country. This forms part of a project supported by the Scottish Industry-Science Partnership involving several partners including the University of Glasgow and the University Marine Biological Station Millport. This questionnaire should not take long and we would be extremely grateful if you would take the time to fill it in and return it to us at the address below.

Once all results have been collected, we will contact all participants with a summary of the findings. Any information that could be used to identify individual people or vessels will be kept strictly confidential.

Vessel Information

Which port(s) do you fish from? If more than one, please put the port which you spend most time at first (main port), followed by any others:

Main port: ______________________________

Other ports: ______________________________

____

____

____

What is the name and callsign of your vessel?

Name: ____________________________________

Callsign: ____________________________________

What is the overall length of your vessel? Please specify metres or feet.

Length: ________________ **(metres / feet)**

What is the engine power in kilowatts? Please specify horsepower or kilowatts.

Power: ________________ **(horsepower / kilowatts)**

Fishing gear

What type(s) of creels do you fish?

a) ____

b) ____

c) ____

d) ____

Please indicate the total number of creels of each type mentioned above that you fish?

a) ____

b) ____

c) ____

d) ____

How many creels are fished per fleet on average?

Number: ______________________________

What is the spacing between creels? Please indicate fathoms or metres.

Spacing: ______________________________ (fathoms / metres)

What is the frame size of each creel? Please indicate inches, centimetres, etc.

Frame size: ________________________ (inches, centimetres, other _____)

What mesh size is used?

Mesh size: ____________________ (inches, centimetres, other _____)

Are escape panels fitted to your creels?

If so, what size are the escape gaps (width and height)?

Width: ____________________ (inches, centimetres, other _____)

Height: ____________________ (inches, centimetres, other _____)

Where are they located on the creel?

Location: ____

What type of entrance is used (e.g. hard, soft eye, top entrance)?

Type: ____

What is the size of the creel entrances?

Size: ____________________ **(inches, centimetres, other _____)**

How many entrances are present on each creel?

Number: ____

Where are these entrances located on each creel?

Location: ____

Fishing

What species do you fish for with creels or pots and in which months? (please tick all that apply)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Brown Crab (*Cancer pagurus*)												
2. Lobster (*Homarus gammarus*)												
3. Velvet crab (*Necora puber*)												
4. Norway lobster (*Nephrops norvegicus*)												
5. Shore crab (*Carcinus maenas*)												
6. Squat lobster (*Munida rugosa*)												
7. Crawfish (*Palinurus elephas*)												
8. Common prawn or 'cameroon' (*Palaemon serratus*)												
9.												
10.												

What are your typical monthly landings (in kilograms) for each species?

Species	**Typical monthly landings**
1. Brown Crab (*Cancer pagurus*)	
2. Lobster (*Homarus gammarus*)	
3. Velvet crab (*Necora puber*)	
4. Norway lobster *(Nephrops norvegicus*)	
5. Shore crab (*Carcinus maenas*)	
6. Squat lobster (*Munida rugosa*)	
7. Crawfish (*Palinurus elephas*)	
8. Common prawn / Cameroon (*Palaemon serratus*)	
9.	
10.	

Please indicate which grounds / areas you fish at different times of year (please write name of ground & tick all months that apply).

Ground/ Area fished	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

How far from your home port do you typically fish? Please tick:

Less than 5 km	
5 – 10 km	
10 – 20 km	
More than 20 km	

What type of bait do you typically use?

Bait: ____

Do you use different bait for different target species? **Yes / No**

How much bait do you typically use per creel? Please indicate kilograms / pounds etc.

Amount used per creel: ____________________ (kilograms / pounds / other ______)

What is your average soak time in hours?

Hours: ____

Does the soak time vary with:

Time of year **Yes / No**

Ground type? **Yes / No**

Weather conditions? **Yes / No**

How many hauls do you make per day on average?

Number: ________________________________

On average, how long do you spend away from port in hours on each fishing trip?

Hours: ________________________________

Approximately how many days in total do you spend fishing per year?

Days: ________________________________

Catches of Fish

On average, what percentage of creels in a fleet would contain catches of fish?

______________________________ %

Does the number of fish caught vary throughout the year? **Yes / No**

If so, when is the greatest amount of fish caught?

Months: ____

When is the least amount of fish caught?

Months: ____

Does the amount of fish vary much between fishing areas or grounds? **Yes / No**

If so, which areas produce the highest catches of fish?

Areas: _____________________________

____

____

Which areas produce the least?

Areas: _____________________________

____

____

Do you land any of the fish caught in creels? **Yes / No**

If so, approximately what percentage of landings are fish?

__________________ %

Are there any fish species which occur regularly in your catches and when? Please tick all that apply

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Cod (*Gadus morhua*)												
2. Haddock (*Melanogrammus aeglefinnus*)												
3. Whiting (*Merlangius merlangus*)												
4. Hake *(Merluccius merluccius*)												
5.Poor cod / Norway pout / bib (*Trisopterus* spp.)												
6. Ling (*Molva molva*)												
7.												
8.												
9.												
10.												

Are there any fish species which are of particular concern to you? **Yes / No**

If so, why?

Why: ____

____

____

____

Do you ever try to increase the amount of fish caught in creels? **Yes / No**

Do you ever try to decrease the amount of fish caught in creels? **Yes / No**

Thank you

That brings us to the end of the questionnaire. Thank you again for taking part in this study. Please return your completed questionnaire to Philip Smith at the address given below.

If you would like to know the outcome of the survey, please provide Philip Smith with your contact details. Alternatively, if you have any other questions you would like to ask about this project, please contact:

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University Marine Biological Station Millport
Isle of Cumbrae
KA28 0EG

E-mail: philip.smith@millport.gla.ac.uk
Web: http://www.gla.ac.uk/marinestation/

Appendix 3. Project outline for creel fishers

The Scottish Industry-Science Partnership (SISP) aims to encourage cooperation between fishermen and scientists in the interests of improving fisheries management.

SISP has funded a project to investigate new ways of surveying fish abundance in nearshore waters, particularly in places where trawl surveys would be unsuitable, because of rough ground or fragile habitats, for example. This project is being coordinated by the University Marine Biological Station Millport and includes partners from the Scottish Sea Angling Conservation Network, Marine Scotland Science, Scottish Natural Heritage and the University of Glasgow.

The methods being investigated include baited cameras, fish traps and angling surveys. At the suggestion of industry representatives on the SISP Steering Group, the project will investigate the potential for obtaining information on fish abundance from bycatch in baited pots or creels fished for crabs, lobsters, prawns and related species. If this approach were to be feasible, the static-gear sector could help to improve the information available for inshore fisheries management.

Initially, the project will investigate this idea by asking fishermen about their experience of catching fish in creels or pots, in face-to-face interviews or in questionnaires, and also by directly recording the numbers and species of fish coming up in creels or pots.

We therefore ask for the help of creel and pot fishermen in this study. Details of individuals and vessels will be treated in the strictest confidence. The results will be reported in such a way as not to allow those taking part to be identified. The project partners have considerable experience of working closely and confidentially with creel and pot fishers in various parts of Scotland.

Thank you,

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